THE RAILROAD AND
ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 45 BROADWAY, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART. . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid.....$3 00
Subscription, per annum, Foreign Countries..... 3 50
Single copies..... 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

MR. J. HOWARD BARNARD, 7 Montgomery Avenue, San Francisco, Cal., is the authorized Western Agent for the JOURNAL.

MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

NEW YORK, NOVEMBER, 1888.

THE new cruiser *Baltimore*, which was launched from the Cramp Yard on the Delaware, October 6, is the largest of the new ships for the Navy yet afloat. The *Baltimore* is intended as a fast cruiser and is not a heavily armored vessel, being furnished only with a protective deck, which covers the machinery of the main part of the vessel, while the engine, magazine, etc., are further protected by the arrangement of the coal-bunkers. The new ship is 335 ft. long over all, 48½ ft. beam, with a mean draft of 19½ ft., and her total displacement will be 4,406 tons. She has two triple-expansion engines, with cylinders 46, 60 and 94 in. diameter and 42 in. stroke, driving twin screws. These engines are expected to develop 7,500 H. P., and by contract she is to make at least 19 knots an hour, with the boilers running under forced draft. At a lower speed she will have a wide cruising range and, with the heavy armament she will carry, will be the most formidable vessel belonging to our Navy until the *Maine* and the *Texas* are completed.

THE most recent addition to the Navy, and the smallest of the new vessels, is the gun-boat *Petrel*, which was launched from the yard of the Columbian Iron Works at Baltimore, October 13. The *Petrel* is only 175 ft. long, 31 ft. beam, and 12 ft. mean depth, with a displacement of 855 tons, but she will carry a heavy armament for a vessel of her size. This will consist of four 6-in. rifled cannon, two revolving guns, two rapid-fire machine guns, and one Gatling gun, making quite a formidable battery. She is not expected to be a very fast boat, the contract speed being 13 knots an hour. The machinery is a triple-expansion engine, capable of working up to 1,350 indicated H. P. For many purposes she is expected to be a very useful boat, but no other of the new vessels is as small, with the exception of the practice vessel for the Naval Academy, authorized by this year's appropriation bill. This will be about the same size, but the plans for it have not yet been prepared.

THE New York Railroad Commission has recently given three hearings to representatives of the railroad companies of the State, in relation to the adoption of a uniform coupling for cars heated by steam. The law prohibiting the use of stoves takes effect this winter, and most of the New York companies are now putting some system of steam heating in their cars, so that the question of couplings is one needing attention, especially by those companies which interchange passenger cars.

The hearings did not result in anything further than to show that there is a considerable difference of opinion as to couplings, and that each company represented is disposed to adhere to the particular system which it has adopted. No progress was made toward uniformity in this respect, and it seems as if it would be a hard matter to secure it. As the different steam-heating systems find their way into use this difficulty is sure to increase. Passenger equipment, it is true, is not interchanged to any great extent, except in the case of sleeping cars, but the difficulties arising from the use of various couplings will still be a source of serious annoyance, and it is to be regretted if nothing can be done toward securing some agreement in this matter.

THE article on Japanese railroads, which is published on another page, is an interesting account of the railroad activity now prevailing in that country, whose people, as is well known, have shown a disposition—strongly in contrast with that of most other Oriental nations—to adopt the mechanical and other appliances of Europe, the railroad apparently being especially attractive to them. At the first glance the peculiar shape of the islands of which the Empire is composed makes it appear an easy matter to plan a complete system, but the fact that the interior of those islands is generally rough and mountainous, a lofty chain of hills running through almost their whole length, interposes many difficulties. Nevertheless the whole of the main island of Nippon can be made readily accessible to the capital and the chief seaports by means of two lines —one on each side of the mountains and parallel to the coast—with branches where needed, and this seems to be very much the system which is being followed. The first lines in Japan were built by the Government, but those now under construction are about equally divided between the Government and the private corporations, the organization of companies having been authorized by the State under fairly liberal conditions, although all the railroads will be under strict Government supervision.

IT is to be noted that not only are railroads making more rapid progress in Japan than in any other Asiatic country, but also that it is the only eastern country which is building its own roads. With the exception of some service as consulting engineers, very little is now being done there by foreigners, while the private companies, which are entering extensively into the work, have been organized by Japanese enterprise, and their money is supplied by native capital. The lines so far constructed have been very profitable, and as the Government has taken steps to prevent the undue multiplication of railroads, it is very likely that they will continue to yield excellent returns. At present railroads are the favorite form of investment, and the

organization of the new companies has brought out a very large amount of money which has heretofore been hoarded up and inactive, and in this way the country will be largely benefited.

The Japanese intend not only to build railroads with their own money, but they also mean that they shall be built by their own engineers, and they have taken pains to train men for that purpose. Many Japanese students have been educated in Europe and America, and the Imperial University at Tokyo has now a very complete engineering school, with foreign and native professors of high standing. It will not be long before the country will be in this respect almost entirely independent of foreign assistance. There must be, however, for some time, a large importation of foreign material; but as workshops of every description have been established and are continually being extended, these importations will include more and more only the raw material, and less and less manufactured and finished products.

Too little attention has been paid by engineers to the study of watercourses, and on a new road the consequences are always troublesome and frequently disastrous. The larger rivers are watched carefully enough and their rise and fall noted; but the smaller streams are apt to be neglected in building a road, and the necessary waterways at their crossings are merely guessed at, and a bridge or culvert put in according to the idea which the locating engineer may form when he sees them. It is not meant by this that there are no exceptions to the rule; locating engineers are found here and there who will take proper care to provide sufficient waterways, but the looser practice is the too general rule, and the results are found in frequent washouts, until the necessities of the operation of the road compel an improvement.

Instances of this could be multiplied, but one which will serve at present can be found near by New York, where a road built some years ago had on a section of 12 miles some 15 water-crossings, every one of which had to be enlarged within two years after it was built, while several were twice altered. Now this road was through an old, settled country, where people could be found who had been familiar for many years with the behavior of the streams, and where a little inquiry and study of the water-marks would have shown what might be expected. Little or no pains were taken, however, and the result was, besides the cost of putting in new bridges, the loss of many thousand dollars from interruptions to traffic, and at least one bad accident from a washout.

In entirely new country data would be harder to obtain than in this particular instance; but much might be learned from careful observation and study of the country. These would take some time, of course, but it would be time well spent and prove economical in the end.

In this connection the notes of a Japanese contributor, which will be found on another page, will be of interest as showing with what care the question is studied there, and the way in which it is taken up and treated.

THE comments of French engineers on American municipal engineering, which will be found on another page, are of interest as showing how our varied systems—occasionally lack of system—in such work strike a foreign observer. Their criticisms appear to be just in some respects, but in others rather severe; but the effect of the latter is somewhat modified by the very handsome compliment to American engineers with which the report concludes.

THE East Tennessee, Virginia & Georgia Railroad will not pass under the control of the Norfolk & Western Company, as expected, the negotiations for its transfer having failed. The road is to be leased to the Richmond & Danville Company, and will continue to be worked under the same conditions as for some time past.

THE ENGLISH VERSUS THE AMERICAN SYSTEM OF RAILROAD CONSTRUCTION.

A CORRESPONDENT has sent us a copy of the *Japan Weekly Mail*—a paper published in the English language in Japan—which contains two articles, one a translation from the *Jiji Shimpô*—another Japanese paper—in which the writer advocates the use of the American system of railroad construction for the railroads of Japan. The article in the *Mail* is a reply to this, and the two form an entertaining, although not very instructive, discussion of this much-disputed subject written by a Japanese and by an English resident of that country. The articles are too long for reproduction in these pages, so that in reviewing them our readers must be content with a brief condensation of the arguments on both sides, which seem worthy of consideration. It may be added that it is not the purpose of this article to give support to either of the disputants, but rather to point out wherein their premises are wrong or their reasoning fallacious, or lacking in comprehensiveness.

The writer in the *Jiji Shimpô* says of American locomotives that "they cost less to construct, burn less coal, are said to be constructed on more advanced principles, are better adapted for steep ascents and descents, and can be more easily stopped than English engines."

To this the *Mail* answers that "it was demonstrated a short time ago in the public press that American locomotives are constructed of inferior material, are about one-third more expensive, are less serviceable, and consume more fuel than English."

This in substance is all that is said of this important branch of the subject by our antipodal disputants, and all who are concerned for the reputation of either American or English locomotives must feel that neither side has made a very strong case.

Quite curiously, while we coincide with the opinions of our *Jiji Shimpô* friend regarding the relative merits of English and American locomotives, yet it would be impossible to agree unreservedly with any one of his reasons for preferring Yankee locomotives to those of British manufacture and design.

With reference to "cost," it is not quite clear whether the price at which locomotives can be bought in the two countries, or the cost of manufacture of engines of the different designs is what the writer means. At present locomotives of the American standard type can be bought for about eight cents per pound, counting the weight of the engine and tender *light*—that is, without water or fuel in either; and made by our best builders. We have no data at hand concerning the present price of locomotives in England, but wrought-iron wheels, plate frames, crank-axles, brass tubes, and copper fire-boxes, which are gen-

erally used on English locomotives cost more, under like conditions, than cast-iron wheels, bar-frames, axles without cranks, iron tubes, and steel fire-boxes. But it will be said that English builders will, if required, make locomotives with the parts named constructed as they are in America. To this it may be said that English cast-iron is not as well suited for making wheels as our best American wheel irons are, that the manufacture of bar-frames requires special and expensive tools and machinery to make them to the best advantage. Of course English builders can and do make locomotives with iron tubes, steel fire-boxes, outside cylinders, and without crank-axles, but that is not their general practice. Locomotive building is like a religion in that, to a considerable extent, it is an accumulation of traditions and a consequence of the needs and experience of those who have practiced it for years past. The American and the English systems have both accumulated a great mass of such experience during the years in which they have been developed. The one cannot be transplanted from the land of its birth and growth to a foreign soil without more or less difficulty, and it would probably be as hard for an English builder to make an American locomotive as it would be to have an English engine constructed in an American shop.

Any one who asserts that the workmanship on English locomotives is not as good as the work done in this country simply makes an exhibition of his ignorance of the magnificent equipment in tools and machinery of the locomotive shops of that country, and of the skill of their workmen. The superiority of American railroad practice consists in its adaptation to the needs of a new country with limited capital. Our railroads were all "hard up" for money when they were built. The repair shops were always poorly equipped with tools, and the appliances for making repairs were insufficient. As a consequence locomotives were designed so as to make their repair easy and cheap. Furthermore, most of our master-mechanics or locomotive superintendents have risen from the ranks, and many of them have been locomotive runners: Therefore, in having their engines built, they gave a great deal of consideration to the convenience and comfort of the men who run them ; more, it is believed, than has been given in England.

Furthermore, our locomotives have had to run over lines with no other ballast than that which mother earth supplied on that part of her bosom where the road was built. The lines were crooked, the rails often worn, and the track rough. The locomotives had to run on such lines or not run at all. As there was no money to reconstruct the roads or put them in proper condition, the rolling stock had to be adapted to run on rough roads. This, as has often been pointed out, is done by adopting the truck, or "bogie" system, as our brethren in England call it, and also by using systems of equalizing levers between adjoining axles so that the weight is transferred from one to the other.

It is, of course, true that English builders can and do make locomotives with outside cylinders ; they use a truck and equalizing levers in many cases, and there is hardly any one thing which is used on American locomotives whose counterpart may not be found on English locomotives. But, as has been pointed out before, there is an unwritten and unwriteable system which experience and tradition has established, and which cannot be carried bodily or transplanted at will from one side of the Atlantic to the other. Matters of proportion which appear trivial, in practice become of the utmost importance, and make the difference between keeping the engine in service or being obliged to lay it up for repairs. Questions of theory, too, under the light of experience often assume quite a different aspect from that which they have without such illumination. Take, as an example, the use of rocker-shafts for valve-gear. An English locomotive designer would generally be willing to submit to mild torture rather than to use rocker-shafts in connection with the valve-gear of locomotives, because to him it appears to be a quite unnecessary and useless complication. Now, while theoretically this position is, in a certain sense, quite sound, on the other hand, the introduction of a rocker-shaft allows the valves, valve-faces, and steam-chests to be placed on the outside of the frames and on top of the cylinders, where they are easily accessible in making repairs. As an answer to the theoretical objection to using what seem to be unessential parts, it may be said that experience has shown that if the rocker-shafts are constructed in accordance with American practice—that is, with a bearing extending the whole length of the shaft—that there is hardly any working part of a locomotive which costs so little to maintain. Its first cost is not very great, and it allows of free access to the valves and steam-chests.

With reference to fuel consumption no one seems to be in a position to be able to speak confidently of the relative economy of English and American locomotives. There can be no doubt of the fact that, under the conditions that they work, some English locomotives are working very economically. Broad deductions from great masses of facts are apt to be misleading, and when the plan is adopted of collecting all the attainable facts and guessing at those which are unknown, almost any position can be proved. In the absence of any data which are comparable, it may be said that there is no reason apparent why an English locomotive boiler, as constructed in that country, should be more or less economical than American boilers as they are made here. The same is true of the use of steam in the cylinders and valve-gear. The fact is, though, that more attention has been given in this country to increasing the capacity of locomotives for doing work than to economizing fuel ; for the reason that there has been more pressing need for it on account of a very common scarcity of motive power. It may be safely asserted that American locomotives are generally worked harder, and do more work in proportion to their weight than English locomotives do. This is due to the fact that the conditions of traffic on English lines do not require the engines to pull as heavy loads as locomotives here must, because here there is often a great deal of lading and little motive power ; and also because it has been learned here that the wages of the trainmen—that is, the locomotive runner, fireman, conductor, and brakemen—amount to more than the cost of fuel, so that to pull a given percentage, say 10 per cent., more load will result in a greater economy than saving the same percentage of the fuel. In other words, the pulling capacity of locomotives is—from an economical point of view—more important than their consumption of fuel is. It of course would be desirable to haul big loads, and to burn as little fuel as possible in doing it. With maximum loads we know of no reliable data from which the performance of English and American locomotives can be compared. American locomotive engineers have no reason to fear such a comparison, how-

ever. The need of pulling very heavy loads here has led to the use of large grates and fire-boxes. This practice has become much more general of late years than it was theretofore, and it seems probable that, in a contest in heavy pulling, our locomotives with large grates and fire-boxes would come out ahead, both in capacity and economy.

Much interest is felt in the arrival of the Webb compound engine, which the Pennsylvania Railroad has ordered, when a comparison of the performance of an English with American locomotives under like conditions will be possible.

One very significant fact, though, which is strong evidence in favor of the American system, is that it has been adopted on the Grand Trunk Railroad of Canada after that road was built by English engineers, and was first equipped with English rolling stock, and all or nearly all its officers were Englishmen. If there is an instance where any of them has not been a convert to the American system after a few years' experience on that line, we have not heard of it.

The Canadian Pacific, built with British capital and the longest single line in the world, has followed in the footsteps of the Grand Trunk and adopted the American system.

So much space has been taken in discussing locomotives that there is no room to devote to cars and other appliances, which will be taken up in the December JOURNAL.

THE PARIS EXPOSITION OF 1889.

THE proper representation of the United States at the Paris Universal Exposition of 1889 is a matter which has not excited the interest in some directions which might be expected. The United States Commission and their assistants have been working very energetically, but have not met with as much support and assistance from manufacturers as they should have received. The time for preparation, under the rules adopted for the Exposition, is now limited, as the final allotment of space will take place November 15, and the shipments by steamer must begin in January next. The Exposition itself will open May 5, 1889, and close October 31, the time for receiving exhibits being from January 1 to March 31, 1889. Under the rules of the Exposition there is no charge for space occupied by exhibitors, and under the law creating the United States Commission exhibits will be forwarded free of freight between New York and Paris, and will also be returned in the same way.

We are informed that while in some departments of manufacture there will be a very creditable exhibit, so far comparatively little has been offered which will illustrate the railroad machinery of the United States. Great interest is felt abroad in American railroads, and for many reasons it would be very desirable to have a full exhibit of our locomotives, cars, and railroad appliances, and it is to be hoped that manufacturers will come forward within the remaining time and make up the deficit in exhibits. In some other departments of machinery there is also abundant room for additional entries still to be made.

It will be of interest to give some particulars in relation to the Exposition generally. The buildings to be used are now nearly completed, and are very extensive, the total area covered by them and by the enclosed grounds being about 3,000,000 square feet. The principal buildings are three in number, called the Palace of Liberal Arts, the Palace of Fine Arts, and the Main Building, in which last the machinery exhibits will be placed. From the information already received, it is expected that the total number of exhibitors from all countries will reach 30,000, and that the exhibits will come from all European countries, except Germany, from South America, and from Mexico, from Japan a very large exhibit will be sent, and from other Oriental countries there are many entries.

The exhibition will be divided into nine groups: 1. Works of Art; 2. Education and Processes Used Therein; 3. Plain and Decorated House Furniture; 4. Textile Fabrics; 5. Raw and Manufactured Products of Mining, Forestry, Chemistry, etc.; 6. Apparatus and Methods of Mechanical Industry; 7. Food Products; 8. Agriculture, Vine-Culture, and Fish Culture; 9. Horticulture. These nine groups are again subdivided into 83 classes. The classes which will especially interest our readers fall under the Sixth Group, and include: Class 59. Machines for various purposes; Class 61. Railroad Appliances, including permanent way, motive power, and rolling stock; Class 62. Electricity and Electrical machinery; Class 63. Appliances and methods of Civil Engineering, Public Works, and Architecture; Class 65. Navigation and Life-saving, and Class 66. Apparatus and methods of the Art of War.

The usual awards of medals and diplomas will be made, although the details of these have not yet been determined. In the last French Exposition, in 1878, the exhibitors from the United States carried off much more than their comparative share of awards, and it is hoped that the same standard will be maintained next year.

The commercial advantages to be derived from a full representation will undoubtedly be considerable, and have been so often mentioned that it is hardly necessary to repeat them.

There is no doubt that, as has been proved before, many of our mechanical appliances need only to be brought to the notice of other nations to secure their adoption, and there will be no such opportunity offered for several years as that now presented at Paris.

The American exhibit, and the interests of those who may take part in it, are in charge of General William B. Franklin as Commissioner-General and of Assistant Commissioner-General Somerville P. Tuck, who have established their offices at 35 Wall Street, New York. All business in relation to the Exposition must be done through these gentlemen, as the French Commission does not correspond with foreign exhibitors, dealing with them only through the authorized representatives of the respective nations.

The law under which the Commission has been appointed appropriated the sum of $250,000, which will be used in defraying the necessary expenses. It may be added that the exhibits, in case the exhibitors are unable to go to Paris or to send representatives, will be cared for free of expense, except that of unpacking and repacking. No duties will be charged by the French Government, except on such goods as may be sold during the Exposition to remain in that country or be consumed there. The French regulations also state that the objects exhibited will have full legal protection aginst piracy of inventions or designs, so that no hesitation need be felt about exhibiting patented machines or appliances.

There is still time to arrange a good railroad exhibit if manufacturers will take the necessary interest, and will do each his share toward it, and national pride, if not self-interest, might well prompt such action.

THE NICARAGUA CANAL.

THE present year will be marked in the annals of American engineering by the actual beginning of work on the Nicaragua Canal between the Atlantic and Pacific oceans. This will be so great and important a work, considered either in its commercial relations or as an engineering work simply, that it must be considered fortunate that it has been planned and will be carried out under the direction of American engineers.

The project is also of interest to those branches of art and industry which will be called into use in its construction, so that its influence will be felt far beyond the commercial and financial circles where its most immediate interest seems, at the first glance, to be centered.

The work accomplished by the promoters of the Nicaragua Canal during the current year, and the manner in which it has been done, give assurance of safe and steady progress in the future stages of the undertaking. With all details covered by minute and careful preparation, the surveying expedition sent out at the end of 1887 fulfilled its task so satisfactorily that it may be fairly said that every problem connected with the construction of the canal is definitely solved, every element of doubt removed, and the path hewn in which the constructors are to follow the footsteps of the pioneers. Meantime the management has pursued the work of preparation and organization in other directions, overcoming obstacles and perfecting plans, so that all is ready for the commencement of active operations in Nicaragua as soon as the charter is obtained for the corporation of execution contemplated by the canal concession—the "Maritime Canal Company of Nicaragua."

The groundwork of the enterprise, the concession from Nicaragua, has been supplemented by a similar grant from Costa Rica, whose territory, by virtue of a recent decision in a boundary arbitration, will touch the canal line in the valley of the San Juan River. These two contracts secure to the Maritime Canal Company an exclusive title to and control over the canal route for a term of 99 years, with a renewal clause. They also invest the grantees with valuable tracts of land, amounting altogether to more than a million of acres, and with all the necessary privileges of pre-emption, free use of materials, immunity from taxes and duties, guarantees of government aid and support, which can facilitate the execution of the work and assure its value when completed.

The charter which is sought for the ultimate company is an Act of Congress, clothing the incorporators with the necessary powers to carry forward the undertaking, but without any financial support or guarantee whatever. Such an act was passed by the United States Senate in February last, but was not reached in the House of Representatives before the close of the present session of Congress. The project will not be allowed on that account to flag or halt, but the necessary corporate powers will be obtained under State laws or from a State Legislature, the legal effect and authority of which would be precisely the same as those of a Congressional charter.

The route of the Canal is from San Juan del Norte, or Grey Town, on the Caribbean Sea, to Brito, on the Pacific, a distance of 169.8 miles; but of this distance only 28.9 miles is canal in excavation, or a little more than one-sixth of the total length of the line. The remainder is free navigation in Lake Nicaragua, the San Juan River, and the basins of the rivers Deseado, San Francisco and Tola. The lake, which is the great natural feature of this route, is a body of water 2,600 square miles in area, with a drainage area of 8,000 square miles, and a mean daily flow, through its outlet, the San Juan River, of 1,272,153,600 cubic feet, or many times the requirements of the artificial works it is destined to feed. The navigation in the lake is 56.50 miles, and in the San Juan River, 64.54 miles. The summit-level, 110 ft. above the sea, will be maintained for 150 miles, beginning at the eastern divide, some 16 miles west of Grey Town, and continuing to the west side of the Tola Basin, less than four miles from the Pacific Ocean. One double lock and one single one on the west end, and three single locks on the east end, will drop the canal to the level of the sea. The width in excavation will be from 80 to 120 ft. at bottom, and from 174 to 288 ft. at the surface; the depth, 30 ft.; but that part of the line in the lake, river and basins will have, throughout nearly the entire length, a width and depth which will render navigation almost as convenient as on the high seas.

A railroad and telegraph line will be built along the entire canal on both sides of the lake, and it will be lighted by electricity. It is also proposed to utilize the water power to the utmost practicable extent, by hydraulic and electric appliances in both construction and operation. The harbors are to be improved by means of piers and breakwaters, and the eastern and western extremities of the canal will be widened to afford convenient access, safe anchorage and dockage. The locks, 650 ft. long and 70 ft. wide within the chambers, will be built with concrete and masonry. The principal engineering features, besides the improvement of the harbors and the construction of the locks, are the rock cut through the eastern divide, and the various dams and embankments. The rock cut is three miles long, at an average height of 149 ft. above the bottom of the canal through that distance. The cost of this cutting is estimated at nearly $12,000,000. By the dam at Ochoa, 52 ft. above the surface of the water, and 1,255 ft. on the crest, the upper 64½ miles of the San Juan River will be converted into an extension of the lake. The dam at the western extremity of the Tola Basin, near the Pacific, will be 71 ft. high and 2,100 ft. on the crest. For impounding the waters to form the San Francisco Basin, in the Eastern Division, five dams will be required, varying from 1,200 to 1,700 ft. in length, but of inconsiderable height, and there will be some secondary embankment along the crest of the impounding ridge, varying in height from 5 to 30 ft. These dams and embankments are substituted for a single dam of 6,000 ft., intercepting the Rio San Francisco near its junction with the San Juan, and proposed in the plan of 1885. There will be a dam of smaller dimensions, and a waste-weir at the east end of the Deseado Basin.

The time limited in the concession for the completion of the canal is 10 years, but it is believed that six will suffice. Fifty million dollars will probably be spent upon the work.

The experience of the surveying expedition which went to Nicaragua in November last, and the members of which have just returned here, is a sufficient guarantee that no unfavorable climatic conditions will interfere with the operations or jeopardize the safety of those who engage in them. Nearly 200 men were in the field for seven months, and not one was lost, and there was not a case of serious illness among them. It has also been demon-

strated that Nicaragua and the neighboring States can furnish plenty of good material for the supply of manual labor needed on the work, and the fresh provisions needed for the sustenance of the working force. An abundance of excellent timber, and all the necessary stone, clay, sand and lime for construction work, are to be found on the line of the canal.

The estimate which has been made in the interest of the company, and which is based on the statistics of the United States Treasury Department and of foreign countries, is that, if the canal were now open, the traffic seeking this route would be about 4,500,000 tons. By the time it is completed—say in 1894—the development of the Northwest Pacific Coast will probably increase this to 6,000,000 tons. With a toll-rate of $2.50 per ton, this would yield sufficient income to pay interest on a capital of $200,000,000.

The great distance saved by the canal—about 10,000 miles—in the voyage between Atlantic ports in the United States and those of the Pacific Coast is well known to all who have considered the subject at all. It is altogether probable that this shortening of the route will give a great impulse to the ocean traffic, and will enable steamships to compete for business which now goes by rail. The advantage given to American merchants in their competition for the trade of the west coast of South America will also be very considerable. The results expected from the canal, however, have been so often set forth, that it is hardly necessary to speak further of them here.

THE QUAKER BRIDGE DAM.

WHEN the new aqueduct intended to bring an additional supply of water to the City of New York was undertaken, it was evident that, while the total yearly supply from the Croton River would be sufficient for the needs of the city for a long time to come, it would fail to meet the demands upon it in the dry season, unless large additional storage capacity were provided. A great storage reservoir was therefore planned, which was to be formed in the Croton Valley by the building of what is known as the Quaker Bridge Dam, which will, when completed, be one of the famous masonry dams of the world, and one of the largest—if not the largest—structures of the kind in existence.

The new dam will close a ravine varying in width from 1,300 ft. at the level of the top of the dam to 300 ft. at the river bed; it will be 270 ft. high from foundation to parapet, and will form an artificial lake 16 miles long, 165 ft. deep at its lower end, and holding about 5,000,000,000 cubic feet of water. It will be nearly 100 ft. higher than any masonry dam yet built.

So great an engineering work naturally excites much attention, and since its construction has been virtually decided on there has been much discussion over its exact location, plan, and details of construction. The location chosen was pointed out by nature, but there was, of course, some opportunity for variation within certain limits. A rock foundation is found at the chosen point, not very far below the surface.

The various plans which had been prepared and presented for the dam were some time ago submitted to a commission of experts—Messrs. Joseph P. Davis, J. J. R. Croes, and William F. Shunk—and they have just submitted an elaborate report to the Aqueduct Commission. This report discusses in detail all the conditions likely to affect the stability of the structure, the forces which it must resist, and the best form and methods of construction to be adopted.

Examining carefully all the circumstances of the case, the experts do not wholly approve of any of the plans submitted, either for exact location or for the section of the dam, and they have therefore prepared plans of their own which are offered for the approval of the Commission. They recommend the building of a dam curved on a radius of 1,146 ft., on the grounds that the structure will be more pleasing in appearance, and also better able to resist extraordinary forces, if built on a curved line. They have prepared a carefully studied cross-section, varying in thickness from 235.5 ft. at the foundation and 133.2 ft. at the level of the river-bed to 27 ft. at the water level and 20 ft. at the parapet, the water side being carried down with a moderate batter and face on a curve. The total area of this cross-section is 27,481 square feet, and the dam, if built on this plan, will contain about 555,000 cubic yards of masonry—a statement which will give some idea of the magnitude of the work.

Some criticisms have been made upon the delay in adopting plans for this work; but it is well to consider that a structure, the largest of its kind in the world, which is to cost nearly $5,000,000, and is to be of vital importance to the future well-being of a great city like New York, cannot and ought not to be hastily planned. The time given to careful consideration and comparison of plans is well spent, especially when this work is in competent hands.

The report is an admirable document of its kind, and it is to be hoped that its recommendations will meet with favor. The Quaker Bridge Dam ought to be, as a successful engineering work, an honor to the city which is to build it and an enduring monument to its designers and constructors.

NEW PUBLICATIONS.

ALFRED KRUPP: A SKETCH OF HIS LIFE AND WORK: AFTER THE GERMAN OF VICTOR NIEMEYER, BY K. W. AND O. E. MICHAELIS. TO WHICH IS ADDED A VISIT TO THE KRUPP WORKS AT ESSEN: FROM THE FRENCH OF CAPTAIN E. MONTHAYE, TRANSLATED BY CAPTAIN O. E. MICHAELIS, U.S.A. New York; Thomas Prosser & Son, No. 15 Gold Street.

The life of a man who, like Alfred Krupp, practically created the largest steel manufacturing establishment in the world, necessarily has the interest which attaches to that of any man who is placed by his genius and attainments above his fellows in any branch of life. That Herr Krupp had genius there is no doubt, for no ordinary man could have overcome the difficulties and the opposition which he encountered or could, in a single lifetime, have developed the obscure little factory which his father left him in 1826 into the immense works which existed under his sole control at the time of his own death 61 years later.

The sketch of his life which is given in the present volume is short and is not burdened with unimportant details, but is long enough to give the reader a good idea of the strong individuality of the man. Necessarily it has much

to say about the Krupp Works, for it may fairly be said that Herr Krupp and his factory were one, so much was his personal influence and oversight felt in every part of the establishment, and so completely was he absorbed in it. It could hardly be otherwise, in fact, for so great an enterprise could not be built up without ceaseless labor; and while assistants enough could be found, the directing impulse must and did come from the head.

The second part of the book gives an account of the Essen Works in their present state, and gives the reader some idea of their great extent and the variety of work done there.

ABOUT BOOKS AND PERIODICALS.

IN its October number the NATIONAL CAR AND LOCOMOTIVE BUILDER publishes the first of a series of articles on Railroad Car Construction, by Mr. William Voss, Assistant Master Mechanic of the Burlington, Cedar Rapids & Northern Railroad. The Author is a practical car-builder of long and varied experience, and is also possessed of technical and theoretical knowledge. The opening number promises well, and if the remaining ones come up to the same standard, they will form a valuable treatise, which is much needed. There is no practical work—indeed no book of any kind—in existence on this subject, and there is no doubt that the publication of a good one will be fully appreciated by those for whom it is intended.

An article appeared in HARPER'S WEEKLY for September 29, by G. T. Ferris, describing the torpedo system at Willet's Point. The article is fully illustrated and of much interest to those interested in this subject. The same paper, in its number for October 20, has an illustrated article on the American Coast and Geodetic Survey.

The MAGAZINE OF AMERICAN HISTORY for October shows, in an interesting way, the contrast between the old and the present methods of travel, in a Diary of a Trip from New York to Niagara in 1828, kept by the late Colonel William L. Stone, well known to old New Yorkers. The trip was made from New York to Albany on steamboat, from Albany to Niagara alternately by stage, canal packet and private carriage.

An illustrated article on American Machine Cannon and Dynamite Guns appeared in the CENTURY MAGAZINE for October. A full description of the Gatling, Gardner and Maxim machine cannon and the dynamite guns of Captain Zalinski is given.

The railroad article in SCRIBNER'S MONTHLY for November is on The Every-Day Life of Railroad Men, by B. B. Adams, Jr. Mr. Adams' experience as a station agent on a New England railroad for many years, and the acquaintance with trainmen's ways and habits necessarily acquired in that position, have enabled him to write from an inside standpoint, and to give an account of the hardships and pleasure of that life.

BOOKS RECEIVED.

THIRD BIENNIAL REPORT OF THE BUREAU OF LABOR AND INDUSTRIAL STATISTICS OF WISCONSIN: FRANK A. FLOWER, COMMISSIONER. Madison, Wis.; State Printers.

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION: Part I. Washington; Government Printing Office.

THE FISHERIES AND FISHERY INDUSTRIES OF THE UNITED STATES: SECTION I, NATURAL HISTORY OF USEFUL AQUATIC ANIMALS. Washington; Government Printing Office. This volume has been prepared through the co-operation of the Commissioner of Fisheries and the Superintendent of the Tenth Census by Professor George Brown Goode, Assistant Director of the United States National Museum, and a staff of associates. It is accompanied by an atlas of 277 plates. It includes a number of useful and interesting monographs on the food-fishes of the United States and the neighboring waters.

AMERICAN JOURNAL OF MATHEMATICS, VOLUME XI. NO. 1: SIMON NEWCOMB, EDITOR; THOMAS CRAIG, ASSOCIATE EDITOR. Baltimore; published under the auspices of the Johns Hopkins University. The present number contains articles by Captain P. A. MacMahon, R.A., on a New Theory of Symmetric Functions; by William Woolsey Johnson on the Integrals in Series of Binomial Differential Equations; by M. Maurice d'Ocagne on Certain Curves which can be Joined to Plane Curves for the Study of their Infinitesimal Properties; and by Professor Cayley on Surfaces with Plane or Spherical Curves of Curvature.

REVISTA DE OBRAS PUBLICAS E MINAS: PROCEEDINGS OF THE PORTUGUESE ASSOCIATION OF CIVIL ENGINEERS. Lisbon, Portugal; issued by the Association.

THIRTEENTH ANNUAL REPORT OF THE RAILROAD COMMISSIONERS OF THE STATE OF MISSOURI, FOR THE YEAR ENDING DECEMBER 31, 1887: JAMES HARDING, WILLIAM G. DOWNING, J. B. BREATHITT, COMMISSIONERS. Jefferson City, Mo.; Tribune Printing Company, State Printers.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present installment of these papers includes Transmission of Power by Compressed Air, by Professor William Cawthorne Unwin; Effect of Rolling and of Wire-drawing upon Mild Steel, by Horace Allen; Balancing Foreign Currents on Telegraph Circuits, by John William Fletcher; Varieties of Clay and their Distinguishing Qualities for Making Good Puddle, by William Gallon; Pumping Machinery in the Fenland and by Trentside, by Lawrence Gibbs; Sewage Flow of Chiswick, by Joseph Hetherington; Railway Engineering in British North America, by Robert Jarratt Money; Abstract of Papers in Foreign Transactions and Periodicals.

ROYALE UNIVERSITA, ROMANA, SCUOLA D'APPLICAZIONE PER GL' INGEGNERI: ANNUARIO PER L'ANNO SCOLASTICO, 1888–89. Rome, Italy; issued by the University.

THE ASHTON VALVE COMPANY: CATALOGUE OF SAFETY-VALVES. Boston, Mass.; 1888.

ILLUSTRATED CATALOGUE OF WOOD-WORKING MACHINERY: WITHERBY, RUGG & RICHARDSON. Worcester, Mass.; 1888.

THE KEYSTONE SEAL AND PRESS: CATALOGUE AND DESCRIPTION. New York; issued by the Keystone Seal & Press Company, No. 170 Broadway.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(Copyright, 1887, by M. N. Forney.)

(*Continued from page 445.*)

CHAPTER XXXIV.

EARLY RAILROAD LOCATION.

The use of the inclined plane and stationary engine far antedate the modern railroad; but in these first examples the inclines were obliged to be straight, and consequently of no great length. In surmounting any great elevation a number of separate inclines had to be used, with short pieces of comparatively level track connecting them. This necessitated a number of separate engines and much more expensive construction.

Among the earlier railroads in this country (particularly in the mountainous region along the Atlantic coast) many were first located so as to include in their future construction inclined planes to be worked by stationary engines; these inclined planes to be operated in connection with the ordinary railroad, and in some cases with canals.

Very few of these inclined planes, however, were built, at least upon any of the roads that to-day are of any importance. This was due to the fact that when railroads were first located in this country, the only precedents the engineers had to guide them in their work were English examples.

In the early development of the locomotive, there was much doubt as to the possibility of a locomotive with smooth drivers upon a smooth rail having sufficient tractive power to pull a load of sufficient weight to pay for the expense of running the engine, and consequently many of the first experimental locomotives were built with toothed drivers to run on a rack-rail, thus doing away with all possibility of great speed and consuming much of the power in useless friction. Even when Stephenson had proved the tractive power of a locomotive with smooth drivers upon a smooth rail to be amply sufficient for all ordinary purposes, still this power was supposed to be much less than it really was, and the influence of grades to be much more than has since proven to be the case.

This led to the English practice of sacrificing all questions of economy in construction, to making the road as nearly level as possible, and also, on account of the long rigid wheel base of the rolling stock, to making the curves as few and of as long a radius as possible. All the lines built in England were comparatively short. The country is nowhere particularly rough, and there never was any question of the amount of capital that could be used. Consequently, at an enormous cost of right of way and construction (about $160,000 per mile), the English railroads have very slight grades and no sharp curves.

As we have said before, these roads were the only examples and education our earlier railroad engineers had in the *art* of railroad location. This led, in the location of part of the Baltimore & Ohio Railroad, to the introduction of inclined planes, in order to overcome the extreme elevations. Before, however, any of them were built, the engineers had arrived at the conclusion that inclined planes were not practicable on a road having a traffic that demanded speed, and that might in time grow to great proportions, and also that if easy grades and curve were an absolute necessity to the running of railroads, with the topographical features of the country and the extremely small amount of capital to be had railroads would be a practical impossibility for many years to come.

But railroads were a necessity, and the only remedy was to make the construction conform with the amount of available capital, and this necessitated steep grades and sharp curves.

It was then practically demonstrated that there was sufficient adhesion between the drivers and rail to overcome any grade that was necessary, and by changing the construction of the rolling stock so as to do away with the long rigid English wheel base, it became possible to introduce curves of a radius of such a length that made comparatively cheap construction possible in almost any class of country. The precedents established in the location and construction of the Baltimore & Ohio Railroad changed the whole theory and practice of railroad location and construction, and with that as a starting-point, there was soon developed what has since become famous the world over as the American Practice of Railroad Location and Construction, by which is meant that the cheapest possible line shall be built that is in no way prejudicial to true economy and the speed and safety of the future probable traffic, and that the above shall be the only limit to the curves and grades that may be used. It was the making possible the running of trains over steep grades and around sharp curves that did away with the necessity of building the majority of the first located inclined planes, and since then has done away with them upon all roads of more than local importance and handling only one class of freight principally, such as some of the coal roads in Pennsylvania and some short roads for exclusively tourist travel.

One more remark before we leave this question of American Practice of Railroad Location and Construction. As we have said, its whole basis and foundation was laid by the first engineers of the Baltimore & Ohio Railroad, and up to the present time, except in a few minor and unimportant details, there has been no material advance made in the principles laid down by those engineers some 60 years ago, with nothing to guide them but their common-sense, habits of close application, and thoroughness in every detail, great powers of observation, and the necessities of the hour.

These qualifications were combined with a fixed determination in all things to arrive at a desired end in a satisfactory manner with simply the available means.

And they usually accomplished their object, and in such a satisfactory manner that 20 years after the location of the Baltimore & Ohio Railroad, Congress recommended to the engineers about to commence the location of a Pacific road that they should study the methods and principles used in the location of that road, and follow them as closely as possible.

CHAPTER XXXV.

PAPER LOCATION.

After an accurate contour map has been made of the section of country through which the railroad is to be located, it is a very simple matter to locate the line that in its general features shall be the best line upon this map.

One great advantage of the contour map is, that by means of it you have, as it were, a bird's-eye view of the whole section of country, with all the prominent topograph-

ical features clearly indicated. In this way it is possible to see at once the relative bearing of each, and examine with care the whole country from one or every standpoint. Although the minor details of the line have to be fitted to the ground in the field, and if an effort was made to actually locate a line in all its details from a contour map, without an accurate and personal knowledge of the country, the minor details would in many respects be extremely faulty, while the general direction might be all right. On the other hand, a line located solely by reconnoissance in the field, without the use of contour maps, undoubtedly would fit well to the ground over which it ran, in its minor details, but owing to the comparatively small area that could be examined at any one time, from any one place, the larger features in the location might possibly be all wrong. So that the only manner of procedure which in every case will insure the procuring of the eminently best line in both the larger and minor details is a combination of the use of the contour map, a thorough knowledge of the country from personal reconnoissance, and a fitting of the line to the ground in every detail in the field.

When an accurate contour map has been obtained, a study of it will at once settle what ruling grade is the most economical. Then, with this assumed grade, we locate a surface line on the map.

Suppose the contour lines are 10 ft. apart vertically, as is usually the case in railroad surveys, with the scale of the map 500 ft. to the inch, the assumed rate of grade 2 per cent. Then, for every 500 ft. of length, the line would rise or fall 10 ft.—that, is from one contour line to the next.

Set a pair of dividers at one inch or 500 ft., according to the scale of the map. Placing one leg at any desired point on any contour line where it is wished to start the location line, and with the other leg cut the next contour line either above or below. Then from this new point step to the next contour line, and so on, with the dividers always set at that distance; that, with the given rate of grade, will give a vertical rise or fall equal to the vertical distance between the contours. This is shown in Plate LVI. The contours are assumed to be 10 ft. apart vertically, and the rate of grade 2 per cent.

Setting the dividers at 500 ft. we start from the point *A*, and stepping from contour to contour, always with this 500 ft., we obtain a series of points *A*, *B*, *C*, *D*, etc., each succeeding one being 10 ft. lower than the one before it, and 500 ft. from it.—that is, a line drawn through these points will have a 2 per cent grade.

This line, as will be seen, is very irregular, and it would not be practicable to build a railroad upon it. Still this line will give the general direction which must be taken by the future railroad.

Using this line as a guide, and conforming to it as nearly as possible, the best general line can scarce be obtained upon paper.

In locating this paper line full allowance must be made for the reduction of the grade upon curves, and also the curves should be offsetted to allow for the introduction of the transition curves as shown at *a*, *b*, *c*, *d*, etc., Plate LVI.

In trying upon the map curves of different radii, in order to use the one best suited to the ground, the beginner will undoubtedly experience some trouble in the use of the dividers for striking the curves, although by a little practice great facility in the use of dividers can be acquired; and when one has acquired this facility they are in every way superior to the many other methods advocated by some locating engineers.

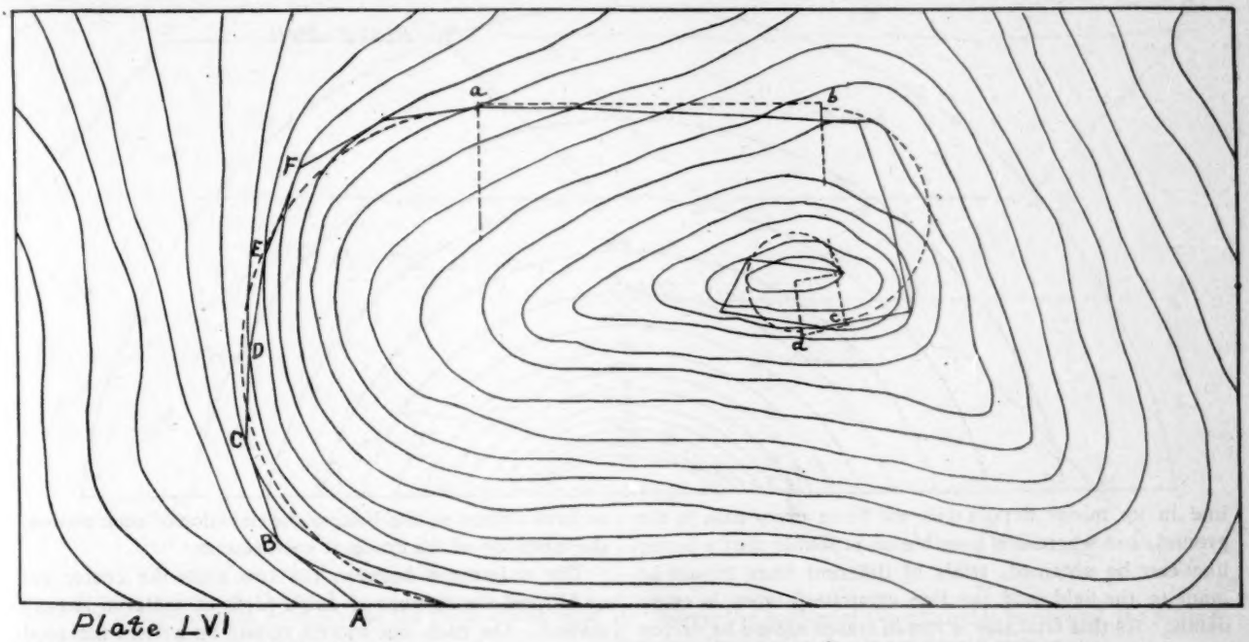


Plate LVI

The following method is often used, and for beginners has some advantages. Let Plate LVII represent a piece of vegetable tracing paper, or, better still, a thin, transparent sheet of mica; upon this draw with a very fine, distinct line portions of curves of different radii from a ½-degree curve to the minimum that will be used, decreasing the radius by ½ degree each time, the radii being the same scale as the contour map upon which it is to be used. In case the curves become too crowded, or there are so many lines as to create confusion, one-half the curves can be drawn in a reversed direction upon the opposite side of the tracing paper or mica.

All the curves upon one side should be drawn from the same center. In case a sheet of mica is used, the lines should be scratched with a fine steel point, and then, to make them distinct, those on one side should be rubbed in with black and on the other with red.

The radius or degree of curvature should be distinctly marked on each curve.

When a sheet of curves (or, as it is sometimes called, a curve protractor) has been prepared, it can be laid on the contour map and slipped back and forth until the appropriate curve has been decided upon and the position of the center pricked through.

Tracing linen should never be used for a curve protractor, owing to its expansion and contraction being very great. In mica there is practically no expansion or contraction, and tracing paper, when used in a room of moderately even temperature, is very little affected.

CHAPTER XXXVI.

FINAL LOCATION.

After the line has been located upon paper, careful notes should be made of its alignment in a field note-book, and from these notes the line run in on the ground. This line in its minor details will not fit in every case to the ground, and where it is possible or probable that a better line can be obtained, trials of different lines should be made in the field, and the line accurately fitted in every detail. As this final line is run in stakes should be driven in at every station, and a plug with a tack point put in at every P. C., P. C. C. and P. T., and as often on tangents and curves as is necessary in order to always have visible from any tack point, one other in each direction that may serve as back-sight or fore-sight.

All of these plugs should be carefully tied in, as explained in Chapter X, care being taken to select the trees or other objects to which these points are tied, at a sufficient distance from the center line, that there will be no danger of their removal, when the line is cleared for construction.

By closely following the above advice, putting in plenty of plugs and carefully tying them, much time and labor can be saved, whenever it is necessary to pick up and re-run any part of the line, either before or after construction commences.

The elevation of each station should be taken, and their correctness verified by checking on the bench-marks that were established along the line on preliminary work.

A careful study should be made of all rivers and streams, as to the size of the opening necessary to pass the water.

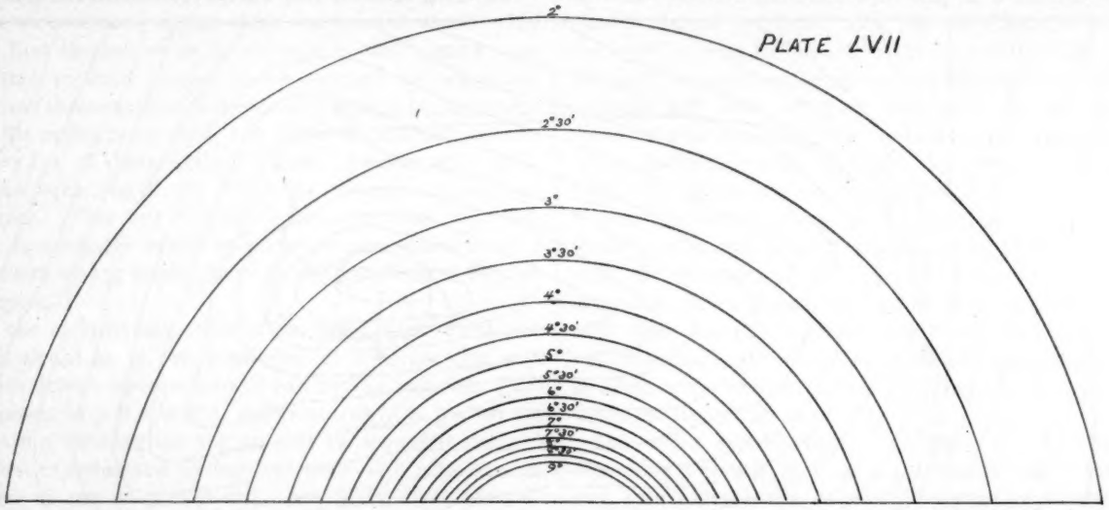
Bench-marks should be established at all places where there is to be any masonry, bridges, or other structures.

From the level notes a complete profile should be plotted, and upon this the grade line established.

This is one of the most important and delicate operations connected with railroad location, and upon the judicious solution of the many problems to which it gives rise and which have been explained in detail in the foregoing pages, depends to a great extent the future success of the road.

On the finished profile should be shown clearly, by means of notes, the class and dimension of every culvert, bridge, trestle, etc., that will be built on the line. Every grade should have marked on it the rate of grade, and the points where the rate of grade changes should be clearly indicated. Along the top of the profile should be indicated the alignment, showing at a glance the P. C.'s and P. T.'s and also the direction of the curves, whether to the right or left, as we face in the direction in which the line is being run. In every cut or fill the material of which it is composed should be noted with as much exactness as possible. When the profiles are finished by the engineer in charge of the work of construction, or for his use, it is often convenient to have written on the bottom the elevation of each station, the elevation of the grade at each station.

PLATE LVII



The differences between the two show the center cut or fill, and the number of cubic yards of material in each station. On each cut and fill should be written the total number of cubic yards of each kind of material in each. Of course this classification of material can only be approximate at this stage of the work. In cases of very heavy work, however, where any error in the class of the material would be an item of great importance in the estimate of cost, there are very often tent pits sunk until solid rock is reached, and then, if deemed of sufficient importance, the tent pit is driven down to any required depth by means of the diamond drill or some other similar machine.

The advantage connected with the use of the diamond drill is that it cuts out a cylinder of the rock, leaving the cone intact, and is so arranged that at any desired point this cone can be broken off and extracted, thus showing exactly the material passed through.

CHAPTER XXXVII.

GRADES, CUTS AND FILLS.

After the establishment of the grades, the elevation of the grade at each station is calculated, and the difference between these elevations and the surface elevations at the same station gives the center cut or fill at each station—that is, the depth of the cut or fill that will be necessary to reach the elevation of the grade line.

These "center cuts" and "fills" should be copied into the

cross-section book that is to be used in the field for putting in the "slope stakes." The heights should be written in a column down the center of the left-hand page, with the sign + before those heights that indicate "cuts" and — before those that indicate "fills." When this has been done everything is ready for putting in the slope stakes in the field.

By the slope stakes are meant stakes driven into the ground on each side of the center stake, forming right angles with the center line at the center stake, and at the points where the slope of the sides of the cut or fill will cut the natural surface of the ground. Thus in Plate LVIII, figs. 1 and 2, let E and B be respectively two center stakes and $E\ G$ and $B\ H$ the center cut and fill. Then will $D\ F$ and $A\ C$ represent the position of the slope stakes—that is, the points where the slopes will cut the natural surface of the ground, when the road-bed is built.

The manner of putting in these stakes, or finding the side distances $D\ E$, $E\ F$ and $A\ B$, $B\ C$, is as follows: The side distances or the distance each way of the slope stakes from the center stake depend upon:

1. The width of the road-bed, $L\ M$ or $I\ K$.
2. The angle of slope given to the sides of the cut or fill, as $D\ L$ or $J\ A$.
3. The natural slope of the surface of the ground, $D\ F$ and $A\ C$.

1. The width of the road-bed for a single track road, of standard gauge in fill, is usually from 14 to 16 ft., and in cut from 2 to 6 ft. under to allow for ditches on each side. For double track it is 20 or 22 ft. and upward, with an increased width in cuts.

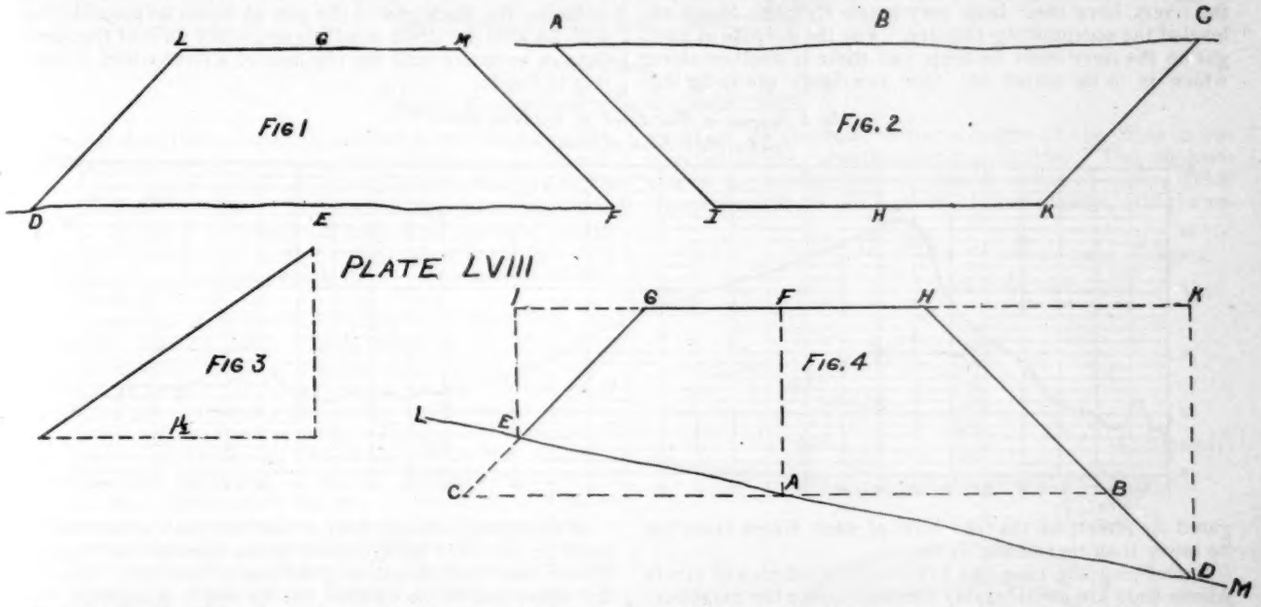
2. The side slopes. The slope of the sides of a fill, when made of loose material just dumped in, should always be as flat as 1½ to 1—that is, 1½ horizontal to 1 vertical (Plate LVIII, fig. 3). Even if the material, such as broken stone taken from a rock cut, appears capable of standing all right at a steeper angle when it is first put in, it is never safe to count on any continuance of this steeper slope, as in a very short time it will settle and run out at the bottom until it has assumed at least a slope of 1½ to 1, and in many cases more, some material requiring as great a slope as 2 to 1.

In the case of cuts, however, this is not the case. The slopes given to the sides of a cut depend in every case upon what the material is of which the cut is composed. In the case of loose earth or sand the slope should be the same as a fill, or 1½ to 1. In gravel, hard-pan, etc., this slope can often be reduced to 1 to 1, and in some cases to ¾ or ½ to 1.

In rock cuts the material can often be taken out with a slope of ¼ to 1 or less.

Of course in every case there are two evils to choose between. If the slope is taken out greater than is necessary, there is a waste of money in moving a useless amount of material. On the other hand, when the slopes are left too steep there is an almost everlasting loss in continually clearing out the cut as it slides in after every rain, until the proper slope has been obtained. As this is much the greater evil, care should always be taken to give the sides sufficient slope, even if it should prove in the end that the material would have stood at a much steeper.

3. The natural slope of the surface of the ground. This we have to accept exactly as we find it in every case.



Where the surface of the ground is horizontal, the setting of the slope stakes is a most simple matter.

The side distances will be one-half the width of the road-bed, plus the center height times the ratio of the side slope. Thus let the width of road-bed be 14 ft., center height, 10 ft., and side slopes, 1½ to 1.

Then the side distances would be

$$\frac{14}{2} + (10 \times 1\tfrac{1}{2}) = 22$$

Where the surface of the ground slopes, however, this is a rather more complicated matter (Plate LVIII, fig. 4). If the surface of the ground was level, with a road-bed $G\ H$, center fill $F\ A$, and side slopes, as shown in the plate, the side distances would be $C\ A$ and $A\ B$. But $L\ A\ M$ represents the surface of the ground; then the side distances would be $I\ G$ and $H\ K$, and the slope stakes would be at E and D. If the surface of the ground was a true plane from the center each way, we could measure the angle of inclination and calculate at once the exact position of the stakes E and D. But even this would be a more or less complicated problem, and, as a matter of fact, the ground surface not being a plane, but very irregular, the angle of which is constantly changing, this method is not feasible.

(TO BE CONTINUED.)

NOTES ON RIVER CROSSINGS AND BRIDGE PIERS.

By M. Otagawa, M.E., Tokyo, Japan.

I.—GENERAL CONSIDERATIONS.

In a mountainous country like Japan, which is also full of running streams, a considerable difficulty is met with in carrying out engineering works. In determining lines of land carriage an engineer must, on the one hand, carry out his work so as to obtain the full benefit from economy of construction, and, on the other hand, to cause the least obstruction to the actual condition of the river in regard to stream and navigation. If the proper arrangements be not made, bridges and embankments become serious enemies to the works of river engineering. Our rivers are all, during the greater part of their course, rapid mountain torrents, and it is only toward the mouth they become sluggish and navigable. Even near the mouth many of the rivers have their beds very much elevated above the level of the surrounding country. For the purpose of navigation the river must be deep, but there is another object which is to be aimed at. Our rice-fields are to be irrigated by rivers, so that the level of such rivers must not be lower than that of the fields.

Such being the case, we have many examples of rivers whose beds are considerably elevated above the neighboring ground. The most noticeable examples of this kind are seen between Kobe and Osaka. Travelers by rail from Kobe to Osaka will remember that they passed through three short tunnels. These tunnels are under three rivers known as Ishiyagawa, Ashiyagawa, and Sumiyoshigawa. In these rivers materials in mechanical suspension were gradually deposited, and at the same time the inhabitants raised the banks. The result was that, when the railroad was to be constructed, the rivers had to be *tunneled under*.

In such cases, when the bed of the river is sufficiently high to be tunneled under, an engineer can carry out his work with comparative ease as long as a flood does not burst the banks. But in case there is not sufficient headroom to carry the line below, or when drainage is difficult from the general configuration of the ground, the river must be crossed by a bridge, and sufficient flood openings must be provided.

Although bridges may be classified under a great many heads, they may be divided into three principal classes—namely, arched bridges (or those of masonry), girder bridges (or those of iron or wood), and those on the suspension principle or the cantilever principle. Each of these may be again subdivided into many classes of different types, which are peculiarly adapted to a variety of situations and circumstances. There are certain situations for which one type of bridge would be as suitable as another. In such cases the choice is left to the judgment or to mere taste. As the span of a bridge increases, the selection is narrowed.

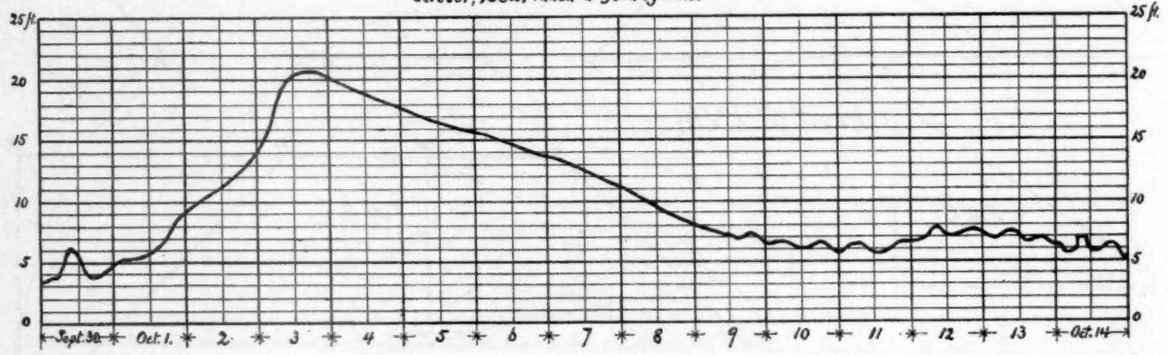
The different kinds of bridges should be chosen according to:

1. The nature of the river.
2. The nature of the traffic.
3. The level of the approaches in their relation to the river.
4. The abundance of certain materials, and their facility of transport and of workmanship.
5. The general features of the site.

In those situations where the traffic is continuous and heavy and foundations are easy, bridges of masonry are most suitable. But such bridges offer greater obstruction both to the stream and to navigation, as compared with other types of bridges, because in them the ratio of the thickness of the pier to the span is very great. For spans between 30 and 150 ft. an iron girder is most economical, and for shorter spans wooden bridges may be preferred to other types when the first outlay must be small. Suspension bridges, or those of the cantilever type, are to be recommended where the span is too great to be crossed by arches or girders at a reasonable cost.

Our present object of inquiry is how best to bridge over a river with the least possible disturbance to the regimen of the river. With a span of 100 ft. or thereabouts, and by reducing the thickness of the pier as much as possible, we will be able to cross most economically and at the same time in harmony with the regimen of a river which is subject to floods.

Fig. 1. Diagram of Flood Level of Arakawa River. October, 1882. Taken at Kawaguchi.



In designing a bridge over a river, accurate observations must be obtained with regard to the level of the highest known flood and the actual condition of the river. Unless the observations be carried out by direct gaugings, the only source of information is to get the highest water level with respect to the levels of flood banks or some fixed works from the statements of people living on the spot.

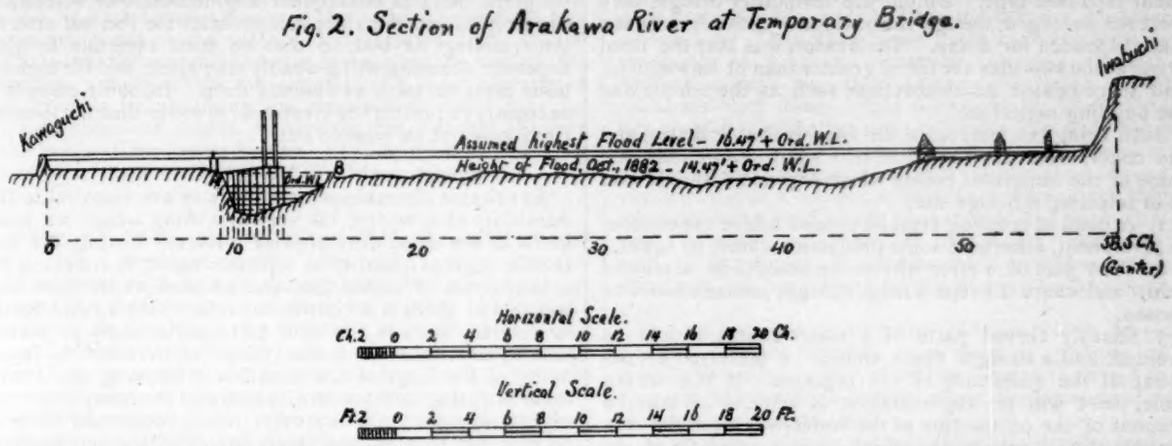
II.—PHYSICAL CHARACTERISTICS OF RIVERS AND CHOICE OF BRIDGE SITES.

The phenomena of floods are the combined result of the irregularities of rainfall and of river-beds, the rain falling upon the ground faster than it can run off. The former is generally beyond human influence, except to a very limited extent as affected by forests, etc., but the latter is within the field of human operation. Little is yet known to us about this subject. Those rivers which have small storage room and flat beds readily overflow. It is possible to calculate the rate of rise in the rivers if we know the nature of the soil, the inclination of its surface, the rainfall, the evaporative power, and the direction of the wind. Floods on chalky soil are of rare occurrence, while in mountainous districts of primary rock their rise and fall is rapid. Our Japanese rivers are, in their ordinary state, merely thin bands of water, but the melting of snow or a continuous rainfall rapidly fills the river channel with an amount of water equal to a high multiple of its average flow. Again, many of our large rivers have their sources on the sand hills, which consist of decomposed granite or Syenite, and the result of clearing away trees in the hills is to wash down the sands and elevate the river-bed, so much so that a line of land carriage can be taken under the bed, as noted above.

In October, 1882, during my stay at Kawaguchi (on the Tokyo & Takasaki Railroad), I met with a great flood in

the Arakawa River, and the aspect of the flood presented several interesting features, to the particulars of which I am going to refer. The Arakawa, in common with other Japanese rivers, is occasionally subject to floods, and when it is submerged by flood waters, its volume is augmented to from five to fifteen times its ordinary flow. The greatest flood within the memory of the oldest inhabitant occurred in 1846. The flood of 1882 is said to have been 1.5 ft. lower than that of 1846, according to the almost unanimous statements of the people living in the neighborhood. I had good opportunities of making observations as to the rise and fall of the flood, of which a diagram is shown in fig. 1. When it occurred the temporary railroad bridge over the Arakawa was in process of construction and suffered damage, from which some important facts may be gathered.

Fig. 2. Section of Arakawa River at Temporary Bridge.



As a general rule, in the Kawaguchi District there are signs of a coming flood. These signs are the prevalence of southeasterly winds, accompanied with long and heavy rains, which warn the inhabitants to take preparatory measures against coming disasters. But it was exceptional in the case of the flood of 1882. The general direction of the wind was northeast, and consequently the residents were far from expecting any flood. The rain began to fall at 11 P.M. on September 29, and it lasted till 9 A.M. on October 2. The rainfall, as recorded at Hongo Observatory, which was the nearest observatory, situated about 75 ft. above the sea-level, amounted in the aggregate to 7.642 in. during the time, and on October 1 alone the quantity was 5.333 in. The duration of the rain in the hilly districts at the upper part of the river must have been greater. At Kawaguchi the flood was first noticed at 10 P.M. on October 2, and the maximum height was obtained at 4 P.M. on October 3. The water began to fall as shown in the diagram.

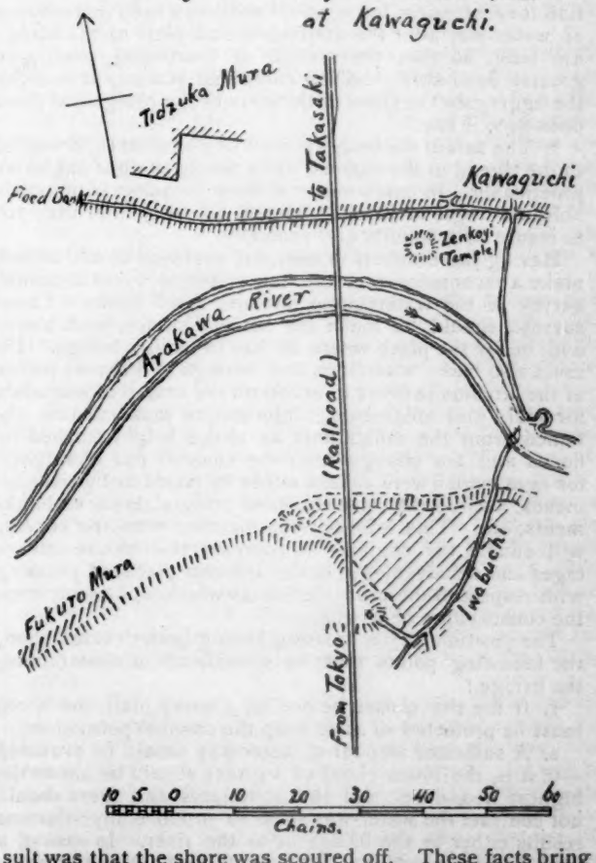
The interpretations of the diagram of the flood wave are as follows :

1. At first the flood-water was carried off in the main channel, which is narrow (see fig. 2, which is a section, and fig. 3, a plan of the river at the crossing), so that the increase in height was somewhat rapid. But when the main channel was entirely filled with water to the line *A B*, then the water had to extend laterally, the consequence of which was to diminish the rate of rise until the sidewise extension was obstructed by the elevated land and flood bank. When these were reached, the rise became again sudden, as shown in the diagram.

2. In the falling stage the converse is the case. The reasons why the river resumed its ordinary state in a comparatively small number of days are : (*a*) Previous to the flood there was not long rain ; (*b*) large quantities of rain fell not at the source of the river, but rather below, and (*c*) the direction of the wind was along the stream.

When the flood occurred the temporary railroad bridge was being built, the piles being of "matsu" (pine) from 32 to 40 ft. in length and 1 ft. diameter at the butt end ; these were driven in about half length by a pile-driver, the ram weighing about 850 lbs., and the last penetration ranging from 0½ to 6 in. In addition to these piles, materials, such as rails, stones, bricks, earthenware pipes, timbers, etc., obstructed the water-way. These materials occupied no less than one-twelfth of the sectional area, at the time when the flood-level was highest. Moreover, in the center of the channel two pile-drivers 33 ft. high mounted on stagings must have formed a great obstruction to the current. Finally they were swept away by the flood. The concave side of the bank was scoured considerably, on account of the narrow, tortuous course of the river as obstructed by the gigantic temple of Zenkoji. The obstruction of the temple mound caused eddies of water, which struck upon the bank a short distance below, and the result was that the shore was scoured off. These facts bring into prominence the following particulars regarding the construction of a bridge :

Fig. 3. Plan of Arakawa River at Kawaguchi.



1. No permanent obstruction, such as the piers of a bridge, should be built in the narrow, tortuous part of a river.

2. A pier should be sufficiently removed from a bank to

allow of the latter receiving only hydrostatical pressure as much as possible.

Besides the temporary railroad bridge, there are two road bridges of fragile construction, one about three miles above and the other about nine miles below the temporary bridge. The former is known as the Toda bridge in Nakasendo, and the latter as Obashi bridge in Senji. These structures are nothing more than wooden bridges of the usual Japanese type. Unlike the temporary bridge, they were not damaged, though the passage over the Nakasendo was suspended for a day. The reason was that the flood areas at the two sites are much greater than at Kawaguchi, and there existed no obstruction, such as the temple and the building materials.

Such being the features of the flood in the Arakawa, and the conclusions derived from it, I shall now enumerate some of the important points which engineers should aim at in selecting a bridge site.

1. A point of crossing must be chosen where the channel is permanent, otherwise some precautions must be taken.

2. That part of a river where the breadth is narrowed below and where it keeps a long, straight course should be chosen.

3. Sharply curved parts of a water-course should be avoided, and a straight reach should be preferred on account of the uniformity of the regimen. If this be not done, there will be augmentation of velocity of flow on account of the contraction of the water-way from the construction of a new bridge which causes scouring of the concave bank.

4. The locality of a crossing should be such that it will give a firm support for the foundation of a new structure.

5. The approaches of the bridge should not require heavy cutting or high embankment.

6. The narrowest section of a river is not the best section for a crossing, for it would not give a sufficient amount of water-way after the abutments and piers of the bridge are built, so that the section of a crossing must give greater flood-area than the narrowest section, at least by the aggregate thickness of the piers of the bridge and flood openings, if any.

7. The axis of the bridge should be placed at right angles to the thread of the current, or as nearly at right angles as practicable. In cases where a skew crossing is unavoidable, the angle of obliquity should not be greater than 70° to insure both solidity and economy.

Having these objects in view, the engineer should at first make a reconnoissance, and is required to make a careful survey of the watercourse and the flood banks. These surveys should be made for some distance, both above and below the place where he has to build a bridge. He must also make soundings and borings at different points of the streams in order to ascertain the nature of materials for piers and abutments. Information must also be obtained from the inhabitants as to the height reached by floods and the changes that the channel has undergone for ages, which were caused either by floods or by artificial means, such as the construction of bridges, dams, embankments, etc. This information, together with the survey, will enable the engineer to compare the relative advantages and disadvantages of the different places of crossing with respect to the probable effects which will result from the construction of a bridge.

The position of the crossing having been decided upon, the following points must be considered in constructing the bridge:

1. If the site chosen be not on a rocky bluff, the shore must be protected so as to keep the channel permanent.

2. A sufficient amount of water-way should be provided —that is, the lower chord of a girder should be above the highest flood-level, and the abutments and piers should not contract the water-way so as to produce any injurious results either to the bridge or to the river. In case of a road bridge, in order to have a sufficient amount of headway, the gradients may be formed accordingly toward the middle point of the bridge, the gradients being, of course, not steeper than the ruling gradient.

3. The headway and distance between piers must be sufficiently great to cause no obstruction to floating materials, such as ice, timber, etc.

4. The piers of the bridge should be placed parallel to the direction of the current in the main channel at least, and there should be provided suitable cut-water quoins at both ends. The size and shape of piers should be sufficiently strong, and at the same time of a nature to offer the least obstruction to the stream.

5. The foundation of the abutments and piers should be durable. In obstructing a certain portion of the water-way by piers, there is consequent augmentation of velocity of the stream, and the river compensates for the lost area by undermining its bed, so that we must ascertain to what depth the scouring will probably take place, and the foundations must be sunk sufficiently deep. In some cases it is necessary to protect the river-bed, in order that the foundations may not be washed out.

III.—WATER-WAY.

As suitable dimensions for water-way are essential to the durability of a bridge, the very first thing which we must know is the flood discharge of a river. During the hot season a great quantity of aqueous vapor is collected by a lofty chain of mountains, and as soon as the cool season sets in there is a continuous rain which causes floods in rivers. Such is the case more particularly in mountainous countries and in the vicinity of the sea. In Japan many of the large rivers overflow after long and heavy rains in spring and autumn, which last for many days and nights together. On the other hand, sometimes there is no rain for months, and rivers are dried up, and the only remains of watercourses then are mere threads of water. How different are the conditions of the watercourses in the two cases! The shallowness of water will, perhaps, impede the crossing of the channel during the latter season of the year; but it is apparent that the bridges and flood openings made under such a state of things are not suitable for the other case, when there are freshets. High flood banks along the stream proclaim the experience of ages, in which the inhabitants have struggled with the water. Again, gigantic stones and rocky beds furrowed into deep holes show that there must have been flood-waves at some other seasons of the year. In country districts we find rivers which are crossed by wading, the water being only ankle deep; but after a heavy rain the passage is necessarily stopped on account of flood. Even in case of rivers which are crossed by bridges, the bridges are often swept away by floods.

Such being the general conditions of rivers which are to be bridged, the question is how to allow for the proper amount of water-way. In some cases valuable information may be gathered from the existence of old bridges at some distance either above or below the new crossing, in judging of the dimensions required for the new one. From careful observations and surveys, combined with information supplied by the inhabitants with respect to the highest flood-level, the engineer can ascertain the probable flood discharge of a river, which will give generally a fair result for the design of a bridge.

The discharge of a river is the product of its sectional area and the mean velocity. The former can be determined by soundings and levelings, and the latter, or mean velocity, can be obtained from the surface velocity reduced by a simple formula. First of all it is advisable to divide the cross section of a river into two or more compartments, according to the depth and character of the bed.

For the majority of Japanese rivers which are subject to floods, there are invariably two distinct compartments, the one being the main channel or the river proper, where water usually flows, and the other, the side spaces or forelands lying between elevated grounds or flood banks, as the case may be.

The physical characteristics of these two compartments are: *First*, the mean depth in the main channel is considerably greater than that in the side spaces; *secondly*, in the former there is comparatively little obstruction, while in the latter there are trees, vegetation, and even buildings. Since lands lying on the sides of rivers subject to floods were untaxed or taxed only slightly, people built houses and temples upon it, and when they experienced floods of greater intensity, they made increased protection for their houses, and thus the obstructions in the side

spaces became greater and greater. Such being the marked differences between the two divisions of a river, the velocity and discharge should be computed for these parts separately, as if there were two different rivers flowing next to each other, which, of course, insures a greater probability of fairer results than taking the whole river at once.

The velocity with which the water passes over the river-bed gradually decreases from the deepest part toward the sides, the maximum velocity in the same longitudinal section being not at the surface, but at some depth below. There are various methods for measuring the surface velocities, among which the simplest and most common in practice is by observing the time which floats take for transit from one station to another, the distance between the two stations being known. The formula which connects the surface velocity and the mean velocity is

$$V m = CVs.$$

Where $V m$ is the mean velocity and Vs the surface velocity, C is a constant varying from 0.8 to 0.85. Messrs. Humphreys and Abbott, during their Mississippi survey, found the mean velocity at once by making observations with a float consisting of a tin tube 4 in. in diameter, which was loaded with shot so as to be sunk under water through the distance equal to the hydraulic mean depth. In cases where there is no opportunity of ascertaining the velocity by direct measurement, the probable value of the mean velocity can be obtained by a formula connecting it with the mean depth, the surface slope, and the physical character of the bed of the river. The formula for velocity, in common with other hydraulic formulæ, is more or less peculiarly suited to the river for which it was originally intended, so that the local conditions of a river to which it is to be applied must closely resemble the original conditions. Nowadays Bazin's formula is generally used.

I will now state some forms of the formula which were adopted by authorities in calculating the discharge of Japanese rivers :

1. The formula used by Mr. E. G. Holtham, late Engineer-in-Chief to the Railroad Department, in calculating the discharge of the Toda-gawa,* is as follows :

A = the area of cross section in square feet.
W = the length of wetted perimeter in feet.
S = the surface slope (or length of channel to fall of 1).
K = a constant.
$V m$ = the mean velocity in feet per second.

$$\text{Then,} \qquad V m = \sqrt{\frac{K A}{S W}} \qquad (1)$$

In the above formula Mr. Holtham assumed the coefficient both for the river proper and side spaces at 8.500, and for the latter compartment he made an arbitrary addition of 5 per cent. to the length of the wetted perimeter.

2. Mr. Van Doorn, late Chief Engineer to the Engineering Bureau, used the following form of Bazin's formula, which he reduced into Japanese measurements :

R = the mean depth of river in *Shaku*.†
T = the surface slope.
$V m$ = the mean velocity in *Shaku* per second.

$$\text{Then,} \quad V m = \sqrt{\left\{11785.7 - \frac{48615.6}{R + 4.125}\right\} R T} \qquad (2)$$

In calculating the discharge of the Arakawa at Kawaguchi, of which the section is shown in fig. 2, I applied the above two formulæ. The result obtained from (1) is 458,203,400 cubic feet per hour, and that obtained from (2) is 460,529,280 cubic *Shaku* per hour. These two results agree pretty closely. Each of the formulæ seems to be suitable for the Arakawa, and it would be generally applicable to other Japanese rivers whose physical nature bears a close resemblance to that of the Arakawa.

* The upper part of the Arakawa River.
† Shaku = 0.994211869o9 ft.

(TO BE CONTINUED.)

JAPANESE RAILROADS.

(Dr. Ernst von Stein in the Vienna *Zeitschrift fur Eisenbahnen und Dampfschiffahrt.*)

THE Japanese people have, as is generally known, for more than a decade past earned for their country the reputation of an Asiatic Europe by their enterprise and progressiveness. Already their railroad system, though almost in its infancy, finds itself in the stage of approaching completion. Depending upon itself and very little on the enterprise of English, American, German, French or Belgian capital—as other Asiatic and South American countries have done—while toleration for foreign capital has been obtained after some difficulty, the work has been and is done chiefly with the capital or accumulated wealth of the Japanese Nation itself, and the first steps toward the construction of a railroad system were taken partly through the organizing work of the Government and partly through the awakening enterprise of the people, following the lead of the State. Europeans have contributed advice, it is true, but have taken very little part in the actual initiative.

It thus happens that by the side of a widely developed system of State railroad lines there is growing up an equally extensive system of private (company-owned as distinguished from State-owned) roads, the creation of which is due to the Nation itself.

If we follow out and study this independent and self-supporting enterprise of an Asiatic people, a contrast lies very near at hand. In India, that densely inhabited country, the English—who at home think the private ownership of railroads the only possible or desirable plan—have been forced to adopt the State railroad system to secure the building of lines, although the Indian people have been under European influence not 20 years only, like the Japanese, but more than 10 times that period.

In the beginning of the Japanese railroad system the State and private railroad systems have taken equal part. Hondo (Nippon), the chief island, where are the two capitals—Tokyo the new, and Kioto the old—and the southern island, Kiushiu, the battle-field of the last rebellion and the home of the most warlike Japanese race, have begun to provide themselves with railroads. Shikoku, the neighboring island, is still without them, but the island of Yesso —the Japanese Northland—has already a line which runs from the coal-fields to Sapporo, the capital, and thence to the port of Otarunai.

The chief interest attaches to the extensive system now under construction, with Tokyo as its starting-point. The last year (1887) was marked by the opening of several important roads, and a brief review of that year will give us a picture of the present condition of the railroads of Japan.

Three lines are—and will be to all future time—the leading railroads of Japan. The first runs from Tokyo to Yokohama, the chief port for foreign trade, which is on the Gulf of Tokyo, in the western part of the island ; this is a State railroad. The second runs from Tokyo northward, and is a private or company railroad. The terminal stations of these two lines in Tokyo are not far from each other, and just outside the widely extended limits which the city occupies, with its million inhabitants, the two are connected by a belt line. The third line, between the other two, reaches out to the northwest to Takasaki and the province of Maebashi, the famous center of the silk industry.

While the first of these lines will unite Kioto and the whole western part of the kingdom with the capital, the second will run through the whole extent of the long, narrow northern end of the island to its extremity, and will be the connection with the island of Yesso. The third is the starting-point for the Nakasendo line, which will run—parallel but not near to the Tokaido line—through the heart of Japan over the mountains to Kioto and the Biwaku Lake, reaching what is industrially and historically the most important district of the kingdom ; a northern branch will lead from Shinanogawa to Kashiwasaki and Niigata, the last a port on the Japanese Sea, which divides Japan from Corea and the Russian territory on the Asiatic Continent.

While Tokyo is thus the center of a radiated or wheel-like system, a similar system of lines has been begun by Kioto, the ancient capital, which has by no means abandoned its rivalry with the newer city, but is in the field also in the modern development of the country, so that its railroad system will be an important factor in the future. The port of Kobe, which may possibly overshadow Yokohama in the future, when its railroad connections are finished; the ancient manufacturing city of Osaka, the center of an important part of the Government business, the mint and the arsenal being there; the neighborhood of the Biwaku Lake, around which great silk and other industries are concentrated; the nearness of the port of Tsuruga, one of the few good ports on the Japanese Sea—all these have importance enough to make the completion of the Kioto system and the connection of the two capitals a welcome event to both.

It must also be noted that the land route from Tokyo to the western end of Nippon and the island of Kiushiu must pass through Kioto. It is not impossible that hereafter, following the example of the Brooklyn Bridge at New York, a railroad bridge may span the narrow Shimonoseki Strait between the two islands, so that trains will run directly from Tokyo to Nagasaki, reducing the time between the two cities. This would have a bearing on commerce with Europe also, for the railroad haul from Nagasaki to Yokohama, about 1,000 kilometers, would reduce by so much the ship voyage.

To go back a little, we find that the first railroad authorized in Japan was the Tokaido line; the first section of this built was the short but important road from Tokyo to Yokohama.

The exorbitantly high cost of this little road, which was in the hands of English engineers, contractors and workmen, taught the Japanese the valuable lesson that they must rely on their own work as much as possible. In fact, the present extension of the Tokaido road from Yokohama, and the other new roads also, are located and built by Japanese engineers and workmen, with but very little help or supervision from foreigners. Even for the iron work of the bridges and other structures only the material has been imported, the construction and putting together having been done in Japan.

The past year (1887) was one specially marked by new extensions and openings, as shown below.

On July 11 the first extension of the Tokaido Railroad, from Yokohama to Kodzu, 48 kilometers, was opened. On July 30 there was opened by the Nippon-Tetzudo-Kaisha—which is the Japanese private railroad company, the second mentioned—the section from Kuroiso to Koriyama, 64 kilometers; and on December 15 a further section from Koriyama to Shiogama, 130 kilometers, making 242 kilometers in all.

It is of interest to follow the average yearly opening of railroads in Japan from the first beginning up to the present time, which has been as follows:

1868–1877, inclusive	14.4	kilometers.
1878–1880 "	8.0	"
1881–1883 "	57.6	"
1884–1886 "	103.6	"
1887	141.7	"

It is now possible to travel in 12½ hours from Tokyo to Sendai, the nearest frequented seaport on the Pacific Ocean, a journey of 344 kilometers, which until recently took four or five days.

In a short time the connection will be completed by rail with Nambu and with Aomori, the most northern port of the island, situated opposite Hakodadi on the island of Yesso. The Tokaido line will also be finished soon to Osaka.

Finally it is well to note the number of charters for private (as distinguished from State) railroads which have been actually granted. These include the following:

1. The Ryomo-Mito line, which is to run to the province of Mito, the home of a powerful race of Daimios related to the reigning family.

2. The Sanyo line, from Kobe by Okayama and Hiroshima to Akamagaseki; this is an important line, which, running along the south coast, will connect the central lines with Cape Shimonoseki at the extreme western point of the island, and will furnish a connection with the future system of the island of Kiushiu.

3. The Kiushiu line, from the port of Moji, opposite Cape Shimonoseki, to Kumamoto, a historic fortified city, which was the stronghold of the imperial army in the last rebellion.

4. The Osaka line, from that city to Imai in Yamato and thence to Nara-Wakayama and Yokaichi.

5. The Kwansei line, from Otsu to Yokaichi, from Kioto to Miyazu and from Fushimi to Nara.

6. The Sanuku line, from Marugame in Sanshu by Tadotzu to Kotshira, a line on the island of Shikoku.

7. The Koshiu line, from Gotemba by Kofu to Matsumoto in Shinshu, one of the ancient strongholds of the Shioguns.

8. The Kofu line, from Tokyo to Hatsoji.

9. The Yamagata line, from Shiroishi to Oshida.

10. The Nikko line, from Utsonomiya, a station on the great Tokyo-Sendai line, by way of Imaichi and Sagashimura to Shikanuma; in Nikko, on this line, there is the most famous and beautiful temple in Japan, which the railroad will make accessible to travelers, so that a large passenger business is expected. This line will also, by a short branch, be brought into connection with Maebashi, and through that place with the important Tokyo Takasaka Railroad.

Thus in a short time Japan will be provided with an extended railroad system, built by native capital alone. In fact, at the present time a railroad enterprise there—as it was in England in the early days—appears a veritable Eldorado for capitalists. The private line of the Tokyo-Sendai Company is now paying over 10 per cent. interest, and it has besides a Government guarantee of 8 per cent.

Nevertheless, in the natural course of events there will soon arise questions which must be settled, and which will spring from the competition between the railroads themselves and between the railroads and the water lines, which will always be an important factor in a country which has such an extended coast line, and so large a part of which is accessible by water.

The rate questions and the rate wars which have made so much noise and so much trouble in Europe—and in America also—are as yet unknown in Japan; but in that country also they will certainly come, and will have to be fought out as in our western countries—to a better and more satisfactory conclusion, it is to be hoped, than we have yet been able to reach.

GEODETIC SURVEYS OF ITALY.

THE geodetic survey of Italy, now nearly completed, has been executed in the most thorough manner, the work having been in capable hands and carried out with the most approved modern instruments and methods of observation and calculation.

The work was begun soon after the present kingdom of Italy was formed; it is in charge of a commission composed of members appointed from the Government departments most directly interested—the Ministries of War, Marine, Public Works, and Agriculture—and of the directors of the principal astronomical observatories.

Several bodies have had a share in the work: The Military Geographical Institute in Florence, the Hydrographic Office of the Navy at Naples, and the observatories at Milan, Padua, Rome and Naples.

The most prominent share has been taken by the Military Geographical Institute, which has furnished the greater part of the men and material for the work. This Institute is a development and enlargement of the Topographical Department attached to the General Staff of the Piedmontese Army, which dates back to 1814.

The work done under the direction of the Commission has been divided into four branches:

1. Trigonometrical and geometrical, including the measurement of base-lines, actual leveling and triangulation, determination of sea levels by observation, etc., etc.

2. Astronomical, including determinations of latitude, of azimuth, of differences of longitude, of intensity of gravity, etc., etc.

3. General work, intended to combine the results of the different surveys.

4. Publications, made with the object of rendering the results obtained accessible to the public and especially to the scientific world.

The work done is so arranged that it includes not only the geodetic surveys, but also the topographical and other work necessary in the preparation of the maps used by the Army, the Public Works, and other departments of the Government. There are now in preparation two large maps of the country which will be among the finest ever executed. One is a topographical map on a scale of 1:100,000, and the other a map for general purposes on a scale of 1:500,000.

The actual work as organized is in four divisions:

1. The Geodetic, by which is done the actual work of triangulation, measurement of bases, etc.

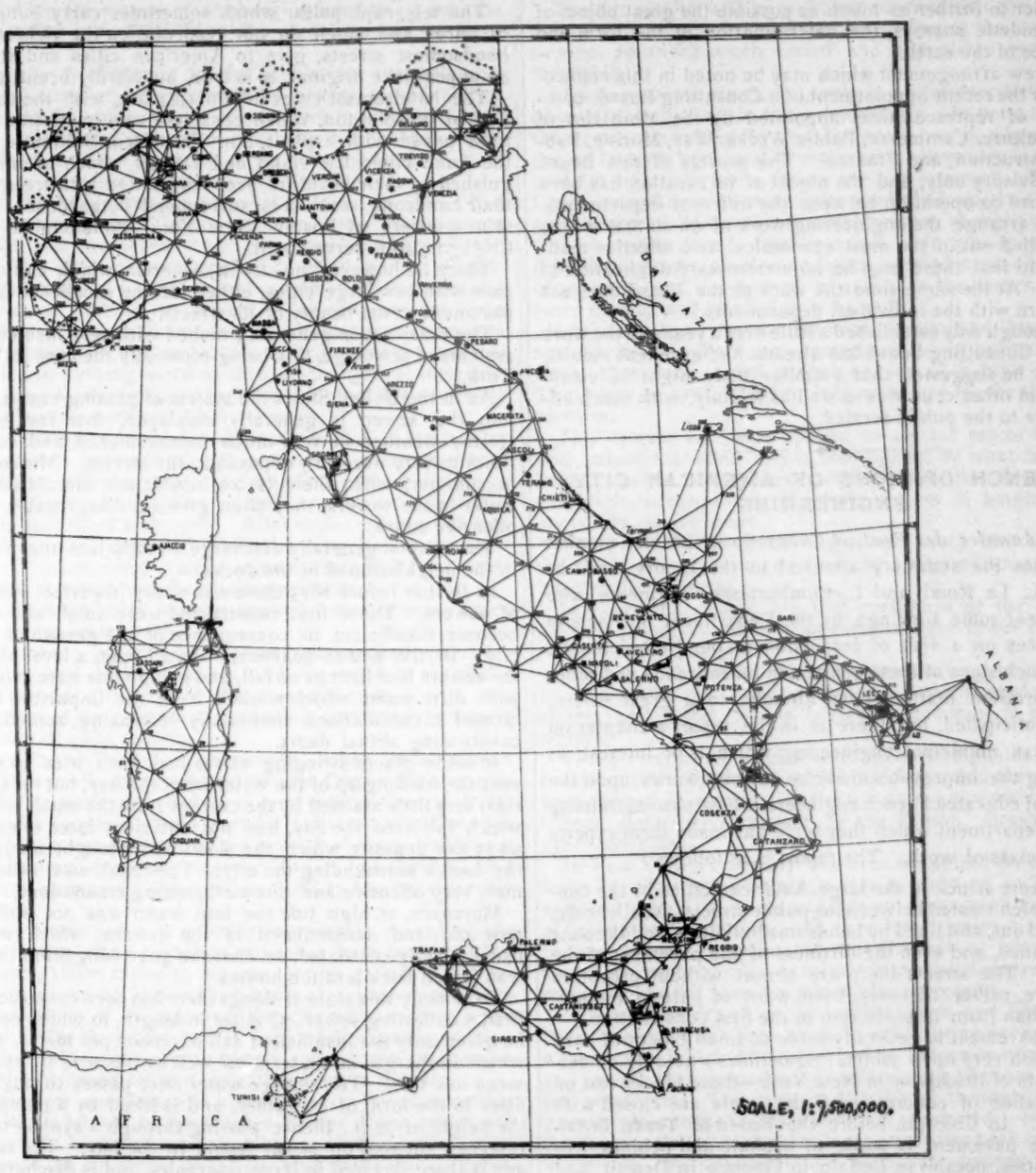
2. The Topographic, in which is done the topographic and general work.

3. The Artistic, in which the work of plotting the surveys and making the maps is developed.

4. The Phototechnic, which has charge of the engraving work, and which follows and studies the latest developments of photo-lithography, photo-engraving, etc.

Experiments are now being conducted with reference to the value of photography in surveying, especially in difficult and mountainous country.

The system of triangulation—now extended over the whole peninsula—is well shown by the accompanying map, which shows the primary triangulation and the several base-lines. For this map we are indebted to the *Revista di Topografia e Catasto.*



GEODETIC SURVEY OF ITALY.

It will be observed that besides the lines in the mainland and in Sicily and Sardinia, a line has been carried across the Mediterranean to Tunis, in Africa. This line was run in 1875–76, some time before that run from Spain to Algeria.

Six base-lines have been established and measured on the mainland and one on the Island of Sardinia. There is still a small gap to be filled, but this will be very soon eliminated by the establishment of an additional base-line near Grosseto in the Tuscan Maremma. The general rule

which has been adopted is to establish the base-lines at a distance apart equal to about 20 of the primary triangles.

The work of observation and calculation is now nearly completed. It is believed that by the use of the best instruments, by careful observations and by complete systems of checking both in observations and calculation, the errors have been reduced to a fraction so small that they may be practically disregarded.

Arrangements have also been made by the Survey to co-operate with similar work in other European countries, in order to further as much as possible the great object of all geodetic surveys, the determination of the form and surface of the earth.

A new arrangement which may be noted in this connection is the recent appointment of a Consulting Board, composed of representatives appointed by the Ministries of Agriculture, Commerce, Public Works, War, Marine, Public Instruction, and Finance. The powers of this Board are advisory only, and the object of its creation has been to secure co-operation between the different departments, and to arrange the engineering work of all so that it may be carried out in the most economical and effective manner, and that there may be no unnecessary duplication of work. At the same time the work of the Board does not interfere with the individual departments.

Although only established a little over a year ago the work of this Consulting Board has already had excellent results. It may be suggested that a similar body might be established in other countries as well as in Italy, with much advantage to the public service.

FRENCH OPINIONS OF AMERICAN CITY ENGINEERING.

Les Annales des Ponts et Chaussées in its last number publishes the summary attached to the report made by MM. L. Le Rond and L. Combarnous, engineers who were sent some time ago by the Department of Ponts et Chaussées on a visit of inspection to the United States. The conclusions of these gentlemen on railroads and other transportation matters have already, to a great extent, been anticipated, but there is in the report a chapter on American municipal engineering which is of interest, as showing the impression made by our city works upon the minds of educated French engineers, whose special training in the department which they serve has made them experts in that class of work. The report is as follows:

We were struck in the large American cities by the contrast which existed between the public streets, usually wide, well laid out, and lined by handsome buildings, and the poor appearance, and even the dirtiness of the pavement of the streets. The streets there are almost without exception defective, rather, however, from want of care in maintenance than from imperfection in the first construction.

The pavement is generally made of small blocks of hard stone with very open joints. Sometimes—notably on certain parts of Broadway in New York—these blocks rest on a foundation of concrete, and the joints are closed with coal tar. In Chicago, before the Board of Trade Building, the pavement is made of asphalt and pebbles. In many cities, notably in Buffalo, in Chicago, in Detroit, and several other cities on the Lakes, extensive use has been made of pavements constructed of round blocks of wood.

In the stone pavement the impermeability of the foundation, the almost complete absence of proper arch to the roadway, and especially the little care taken in maintenance and cleaning, have resulted in a very bad condition, and the streets are almost always covered with black and slippery mud.

The wooden pavements are very much better, as a rule.

The sidewalks are usually of flag-stones, and very little importance is attached to keeping a good surface or smooth joints; consequently, little streams frequently establish themselves, the borders of which are more or less well defined, and which carry with them dirt and refuse, sometimes giving the passengers much trouble. Nevertheless, it is only fair to say that this custom does not much disturb Americans. The limits of these streams are usually found near the borders of the sidewalk, and it is customary in America to cross the roadway only at the intersection of the streets, where there are usually placed cross-walks which are a continuation of the sidewalk. These cross-walks are, besides, the only place where one can avoid the mud in wet and thawing weather, and where there are usually stationed policemen to make way for foot passengers when the road is crowded with vehicles.

The telegraph-poles, which sometimes carry hundreds of wires, and which do not respect even the richest and handsomest streets, give to American cities and streets an appearance original, it is true, but hardly beautiful.

The handsomest cities in America are, with the exception of Washington, which possesses very handsome avenues paved with asphalt, San Francisco, Baltimore, and the Lake cities, Cleveland and Detroit, which are distinguished by their beautiful avenues planted with trees, and their handsome residences surrounded by gardens. Certain quarters of Boston, New York, Philadelphia, and Chicago also deserve credit.

There is, however, no city in America which can compare with our large cities, either for the excellence of its pavement or the beauty of its streets.

The cities are in general furnished with very insufficient systems of sewerage, this being especially the case in New York.

As in the United States the system of passing everything into the sewer is generally employed, this results in stormy weather in very much inconvenience, and sometimes in very unseemly deposits in the streets. Moreover, in summer, when there is an insufficient circulation of water in the sewers, they often give out disagreeable and offensive odors.

The sewers generally discharge directly into the rivers in the neighborhood of the docks.

In Boston before 1875 there was a very imperfect system of sewers. Those first constructed were small and had become insufficient in consequence of the growth of the city. In the newer quarters, situated upon a level plain, the sewers had little or no fall, and at high tide were flooded with dirty water which washed back the impurities and formed accumulations continually increasing, sometimes constituting actual dams.

In some places swinging valves had been tried to prevent the backing up of the water from the bay, but the ebb-tide, very little assisted by the current from the small rivers which fall into the bay, had not sufficient force to carry away the deposits which the flood-tide brought up upon the banks surrounding the city. The result was, in summer, very offensive and disease-breeding emanations.

Moreover, at high tide the foul water was not able to flow out, and accumulated in the sewers, which were usually badly ventilated, so that the gas rising from them was forced back into the houses.

To remedy this state of things there has been constructed first, a collecting sewer, 3¼ miles in length, to which could be given only the insufficient fall of 0.0005 per meter, and which discharges into a terminal well or basin 14 ft. below mean low tide. The sewage water next passes through a filter in the form of a strainer, and is lifted by a pump to the height of 34 ft., thence passing through a syphon to a reservoir situated on Moon Island in the bay. The sewage is there received in large reservoirs, and is discharged on the ebb-tide at a point north of the island where there is a current of about one knot an hour which carries everything out to sea.

The machinery includes two compound engines of the Wooster system, running at a speed of 12 revolutions per minute, and each operating a direct single-acting Leavitt pump. These engines are each of 300 H. P., and their duty is from 25,000,000 to 35,000,000 gallons per day.

There is, besides, an auxiliary plant consisting of two Worthington pumps, each having a duty of 25,000,000 gallons per day.

At the discharge of the pumps the sewage water runs through two depot sewers about one-quarter of a mile long, which are intended to prevent the carrying of solid matter into the syphon, which is carried under the bay at a depth

of about 140 ft. below mean tide. These sewers are cleaned by a valve-boat. If deposits form in the syphon they are cleared away by a ball-cleaner.

In the interval between two tides the reservoirs on the island receive, on an average, 12,000,000 gallons, and they can be emptied in 30 minutes. The amount collected sometimes increases to almost twice the average, and it can then be discharged usually in 40 minutes.

The city of Providence has also recently improved its system of sewers; the arrangements which are there applied under the system of discharging everything into the sewer, differ very little from the methods used in England.

The city of Memphis on the Mississippi formerly possessed a very imperfect system of sewers, to which they attributed the epidemics of yellow fever in 1867, 1868, and 1869. Since the sewers of that city have been reconstructed the yellow fever has never been epidemic.

The same result has followed in New Orleans.

The city of Denver did not exist in 1860; in 1886 it had 65,000 inhabitants. The construction of sewers was begun in 1880, and the expense had increased in 1886 to $354,000. The system there applied is original, the notable point consisting in the use of automatic apparatus for cleaning or flushing the sewers. The ordinary discharge of water is not sufficient to give a continuous current or prevent deposits, but under this arrangement the water is retained in flushing cisterns and discharged at intervals, producing a rapid current, and washing out the sewers so as to dispense with any other cleaning.

This system, which was devised by H. C. Lowrie, City Engineer, is very simple. It consists of a cistern where the water collects, which is furnished with a discharge tube in form of a syphon, closed by a valve, which is a rubber ball filled with sand. After each cleaning this ball falls back on its seat and closes the pipe; when the pressure of accumulated water increases to a sufficient point the ball is raised and the discharge made.

This system could without doubt be used in many cases to great advantage with us.

Americans, generally, are great consumers of water, for washing and other purposes, and ice-water is especially their favorite drink. For this reason the cities as a rule have spared no expense in procuring an abundant supply of water of good quality.

The city of New York constructed, when its population was still small, an aqueduct from the Croton River carrying water from that river to a reservoir in Central Park. The old aqueduct could furnish 118,000,000 gallons per day, but in consequence of the growth of the population it had become necessary to force it to its full capacity, and by thus increasing the work its solidity was considerably affected.

New works are now actually in progress, including the construction of an aqueduct 33½ miles long to carry 250,000,000 gallons a day to the city, or 100 gallons a day per inhabitant on an established basis of 2,500,000 people, a figure which, it is expected, the city will reach in a few years. The aqueduct has, in fact, a full capacity of 320,000,000 gallons in order to supply not only the city proper, but the Annexed District recently added to the city.

This new aqueduct will be supplied by the construction of what is known as the Quaker Bridge Dam, which will be 277 ft. high and 1,422 ft. long, and which will largely increase the amount of water retained in the storage reservoir at the starting-point.

The city of Boston consumed in 1885 about 32,344,000 gallons of water per day on an average; this was brought from the Sudbury River, Lake Cochituate, and the Mystic River, and the supply was 71 gallons per inhabitant per day. The water-works at Boston are widely scattered, and it would be impossible to give in a brief space any idea of them. We can only say that additional works, completed in 1885, consisted of several earth dams over 30 ft. in height protected by concrete and riprap, and several conduit-bridges, one having an arch of 130 ft. The object of these works is to increase the supply to 40,000,000 gallons a day.

It is well known that the celebrated Cabin John Bridge was built in 1859 by General Meigs as part of the aqueduct which carries the waters of the upper Potomac to Washington. This admirable work is, after 30 years, in a perfect state of preservation, and does not show any of the cracks so often seen in works of this class.

As a rule the cities take their waters from rivers, as much as possible above the thickly inhabited points, or from lakes. At Chicago the water-works get their water from Lake Michigan, through two tunnels, running out two miles into Lake Michigan, and it is distributed through the city without any intermediate reservoir.

These examples will be sufficient to show that the problem of water supply has received, according to the circumstances, solutions much varied and sometimes very remarkable.

Lighting varies much, not only in different cities, but often in one city and in the same streets. In most towns the streets are lighted by gas, but every one is allowed to put up his own light, and in many cases advantage is taken of these private lights to reduce the city expenses. Sometimes, even, they are content with the light from the stores, and the streets of American cities present at night a very curious appearance. One sees not only gas-lights but different systems of electric lights, carried upon all sorts of supports, and it can often be said that the passenger is more dazzled and blinded than helped.

Large squares, as, for instance, Union and Madison squares in New York, are sometimes found lighted by a circle of electric lights placed on top of a high mast. These can be lowered when it is necessary to change the carbons.

This system has been applied to a great extent in Detroit, where the whole city is thus lighted by what may be called electric chandeliers, carried upon iron towers of very light construction about 60 meters in height and about 200 meters apart.

These throw out a steady light, very much like that of the moon, and give the beautiful city of Detroit an appearance entirely unique.

In Cleveland, where are the workshops of the Brush Electric Company, there is an electric light tower 250 ft., or 75 meters in height.

The use of the electric light is now spreading very rapidly in America for lighting railroad stations, workshops, streets, and hotels, and is becoming common in private houses.

There exist in American cities many companies which furnish electricity to houses and buildings, and there have been formed in many cities electric companies which distribute electricity furnished by the Edison, Brush, and other machines.

In New York a company has been organized on a large scale to distribute steam. It has a plant of 42 Wilcox boilers of 250 H. P. each, and has put down over six miles of pipes of 15 and 16 in., and 13 miles of lesser diameter. In these pipes it is estimated that the loss of heat is not over 5 per cent. So far as we are informed, however, this company has not been yet financially successful.

In some Western cities, as in Pittsburgh and Buffalo, a commencement has been made in substituting for coal the natural gas, which is discharged in immense quantities and at very high pressure by wells similar to those bored for petroleum. This gas is distributed through underground pipes to the points where it is consumed. In Pittsburgh, especially, it is used in large quantities both in manufacturing establishments and in private houses for domestic purposes.

In conclusion, it may be said that, if we recognize the difficulties under which they have had to labor, and the immense works which it has been necessary to construct in a short time, the American people have shown qualities which will make them the first engineers in the world. Their great superiority is in their quick appreciation of circumstances and the advantage which they take of them, and also in the fact that they are free from preconceived ideas. For them every problem is soluble, because they always take care to put it well. While their cities are in some respects inferior to ours, it is more because of their rapid growth and the lack of time, than because they do not appreciate the situation, and have not the ability to meet it.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 458.)

CHAPTER XXI.

THE COCKERILL 100-TON HAMMER.

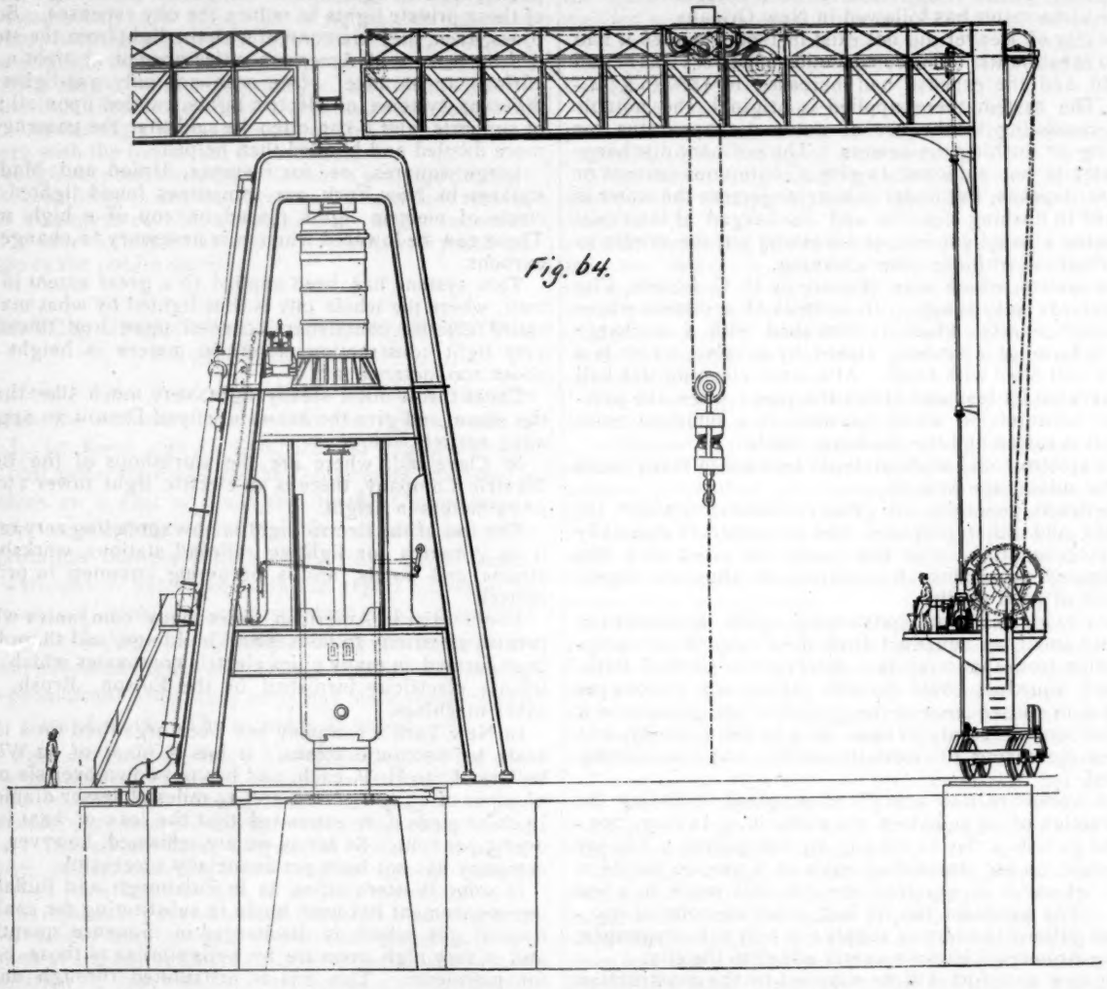
This single-acting hammer was built by the Société John Cockerill, at Seraing, Belgium, for the Terni Steel Works in Italy. A very fine model in wood was shown at the Antwerp Exposition in 1885. Of the accompanying illustrations, fig. 64 is an elevation, fig. 65 a side elevation, and fig. 66 a plan. These illustrations give an idea of the form and dimensions of this enormous tool, which was especially made to forge heavy guns and armor-plates for ships, and generally forgings of the very heaviest description. The engravings show also the arrangement of cranes, etc., by which these enormous forgings are handled. Fig. 67 shows the piston-rod and hammer on a larger scale.

We cannot properly describe this hammer without speaking also of the arrangement of the reheating furnaces and of the building which shelters it.

There is at Terni a fall of water of considerable volume, and of a height of 180 meters; this is used to drive four air-compressors, which can furnish each 24 hours 50,000 cubic meters of compressed air, having an effective pressure of 5 atmospheres. The motive power of the hammer is therefore compressed air, and not steam, as is usually the case.*

The hammer rests upon two enormous masses of masonry carrying two foundation plates upon which the frames are placed. Immediately below these foundation plates is a seat composed of a block of cut stone 1.000 meter thick, and below this again is a mass of masonry set in cement.

The foundation plates are in two parts, joined together by heavy bolts, and each of these two parts is held in place by eight large bolts, four passing through the legs and four at the corners of the plates. These bolts have a section of 0.180 square meter, and run down 6.200 meters into the masonry foundations; at that depth they pass through a guard-plate of iron 0.125 meter thick, and are held by keys bearing upon this plate.



THE COCKERILL 100-TON HAMMER.

The anvil-block is completely independent of the frames and supporting plates. Its total height is 5.500 meters, its general form being that of a truncated pyramid, with a rectangular base of 7 by 6 meters in size. The top is square, each side being 3.600 meters in length, and the total weight is 1,000 tons. Owing to the difficulty of moving so large a block it was necessary to cast it in place, and this operation succeeded so well that it is hoped that the block is entirely sound, and will be able to resist properly the shocks which it is called upon to receive. This anvil-block rests upon a foundation of oak blocks solidly bolted together.

* The Allevard forges in Isère, France, have also large hammers worked by compressed air.

The frame, built entirely of wrought-iron plates and angles, carries the steel slides and the cylinder above.

Instead of employing two legs of cast iron for the lower frame, according to the general practice, the designer of this hammer preferred to use four legs, as stated above, of wrought-iron plates and angles giving very great resistance. This method of construction, which gives the tool a very light appearance, had been used since 1880 by M. Arbel for several hammers, among which there is the 40-ton hammer for forging wheels, which has been described above. This hammer has acted very well, and has not required any repairs, which would certainly have been the case if an ordinary cast-iron frame had been used, and had been called upon to support the very heavy blows which are necessary in this kind of forging. Moreover, this arrangement of four legs is much preferable to that ordinarily used, as it gives a very wide base, which secures complete stability and abundant space for handling heavy forgings. These legs are joined at a certain height by four plates forming braces, two of which serve to support the slides; they are prolonged around and above the cylinder and form a top or hood, serving to carry the cranes.

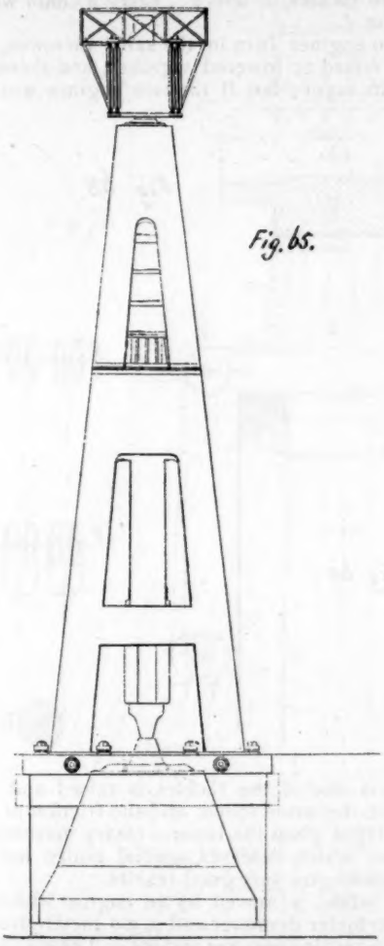


Fig. 65.

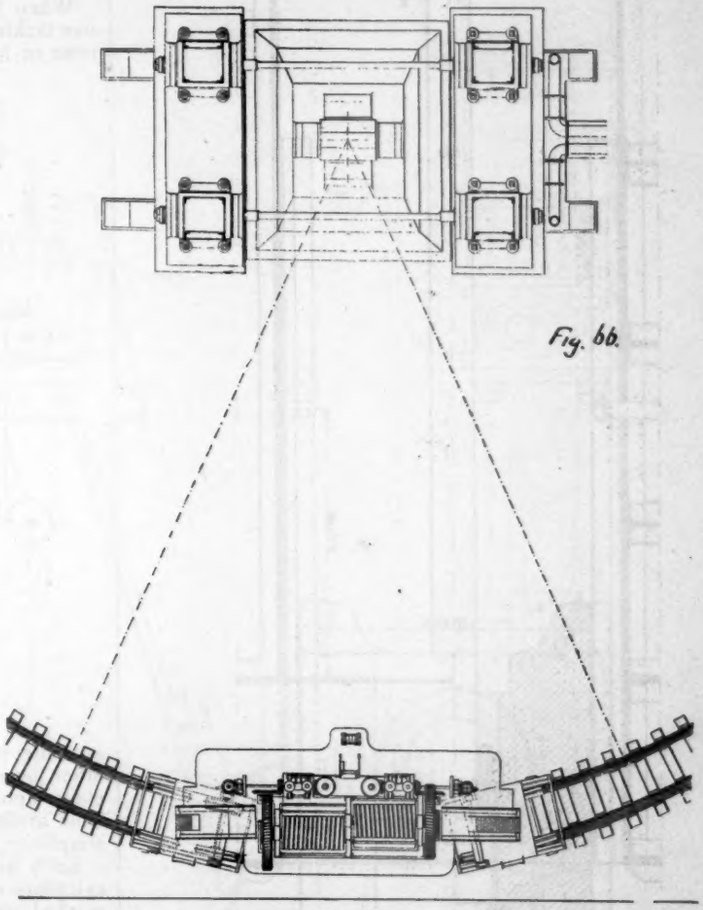


Fig. 66.

The clear distance between the legs is 8.000 meters, and the clear height under the braces is 3.400 meters. The total height from the ground to the pivots upon which the cranes rest is 19.600 meters.

The slides are made of two pieces of steel of a section shown in fig. 68, which are bolted on uprights made of plates and angles. The cross-section is widened in the middle, and a corresponding groove made in the side of the hammer-block works upon this portion. Very heavy catches or holding dogs are provided in order to support the hammer when it is necessary to make changes.

The cylinder is made in two parts, one above and one below, the latter serving also as a table or upper frame; this is supported by the frames and securely bolted upon the cross-pieces which brace the frame together. This lower part carries also the apparatus for distributing the compressed air, which is single-acting and is composed of two balanced valves with double seat. The diameter of the cylinder is 1.920 meters, and its total height 6.500 meters.

The movement of the valves, and also that of the catches, is made by means of bell-cranks worked by levers handled by the hammerman, who is placed upon a platform 4.800 meters above the ground. In this position he is not only sheltered from heat and sparks, but can both hear well the orders which are given him and see the signals which are made.

The piston is made of cast steel; the piston-rod is also of steel, and is secured to the piston by a nut, which is further secured by a ring sprung on hot. The piston is fastened to the hammer-block by means of steel rings, the lower one being in a single piece, and the upper one in two pieces, held by heavy keys.

The weight of the moving parts—that is to say, the hammer, the die, the piston, and the rod—is 100 tons. The stroke of the piston is 5 meters, so that the work produced in the descent of the hammer will be 500 meter-tons. The diameter of the cylinder being 1 920 meters and that of the piston-rod 0.360, the exact section upon which the pressure operates to raise the hammer is 2.900 square meters. The pressure of the compressed air being 5.165 kilos. per square centimeter, the total lifting pressure will be 150 tons. If we assume a coefficient of 15 per cent. for the friction of the piston in the cylinder, the rod in the stuffing-box and the hammer in the slides, we see that this cylinder will have sufficient lifting force to move with all required speed, and that the weight of the striking mass could be even increased should it be necessary.

This hammer is served by two cranes, turning around its axis. These cranes are of the same type, and differ only in power, one lifting 100 tons and the other 150 tons.

The pivot to which they are attached is double, and is composed of two hollow pivots of unequal height, turning one inside the other upon a steel seat bolted securely to the summit of the hammer frame. These pivots are furnished with flanges, to which are secured by bolts square

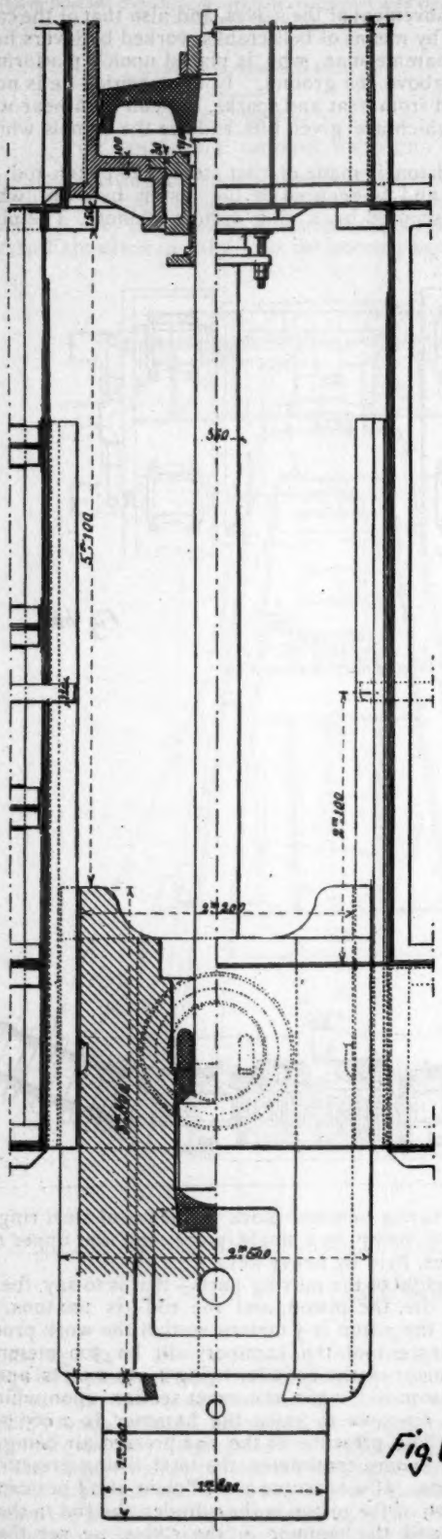


Fig. 67.

boxes made of wrought-iron plates and angles, to which are fastened the arms of the crane. These cranes are held at one end by this pivot fixed to the frame, but at the outer end are supported on separate upright posts resting upon trucks which move on a circular railroad track. The arms of the crane and the upright posts are made of plates and angles; the arms are 2.200 meters in depth and are 21 meters long.

On the upright posts which carry the outer end of the arms are placed the engines which work the cranes and which operate by compressed air. These give the following movements:

1. The motion of the large crane around the hammer.
2. The hoisting and lowering of the load.
3. The change of the load in a horizontal direction.
4. Movement of rotation of the load.

The last is made in the manner shown in fig. 69. The chain is led from the drum *T*, worked by the engine, on to a guide pulley *G*, and then passes from the two pulleys to the car *C*, and thence to the tackle *P*. The same arrangement is made for the second drum *T'*, driven by the second motor. The two tackles, *P* and *P'*, carry a chain which supports the ingot *L*.

When the two engines turn in the same direction, the two tackles are raised or lowered together, and therefore raise or lower the ingot; but if the two engines work in

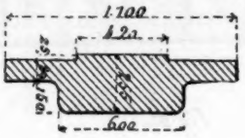


Fig. 68.

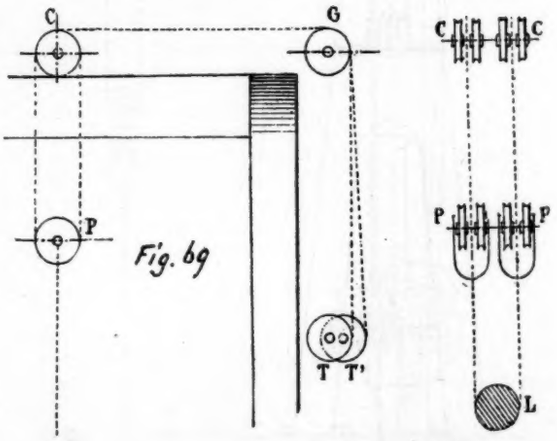


Fig. 69.

opposite directions one of the tackles is raised and the other lowered with the same speed, and the friction of the chain upon the ingot gives the latter a rotary movement. This arrangement which deserves special notice for its simplicity, appears to give very good results.

Each hoisting wheel is moved by an engine with two cylinders of 0.200 meter diameter and 0.300 meter stroke, worked up to 200 revolutions per minute. These cranes have a total radius of movement of 21 meters.

The principal dimensions of this hammer are as follows:

Weight of working parts.....	100	tons.
Maximum stroke of hammer...	5.000	meters.
Diameter of cylinder.....	1.920	meters.
Diameter of air-valve.....	0.340	meter.
Diameter of exhaust-valve.....	0.420	meter.
Width of the hammer.....	2.200	meters.
Clear space between the frames.	8.000	meters.
Clear height under the frames..	3.400	meters.
Height of the air cylinders.....	6.500	meters.
Height from the ground to the level of the crane pivot.....	19.600	meters.
Height of the anvil-block.....	5.500	meters.
Surface of the base of the block.	42.000	sq. meters.
Surface of the top of the block.	12.960	sq. meters.
Total weight of the anvil-block.	1,000	tons.

The air cylinder is made in two pieces, as already stated; the usual working pressure employed is 5 atmospheres.

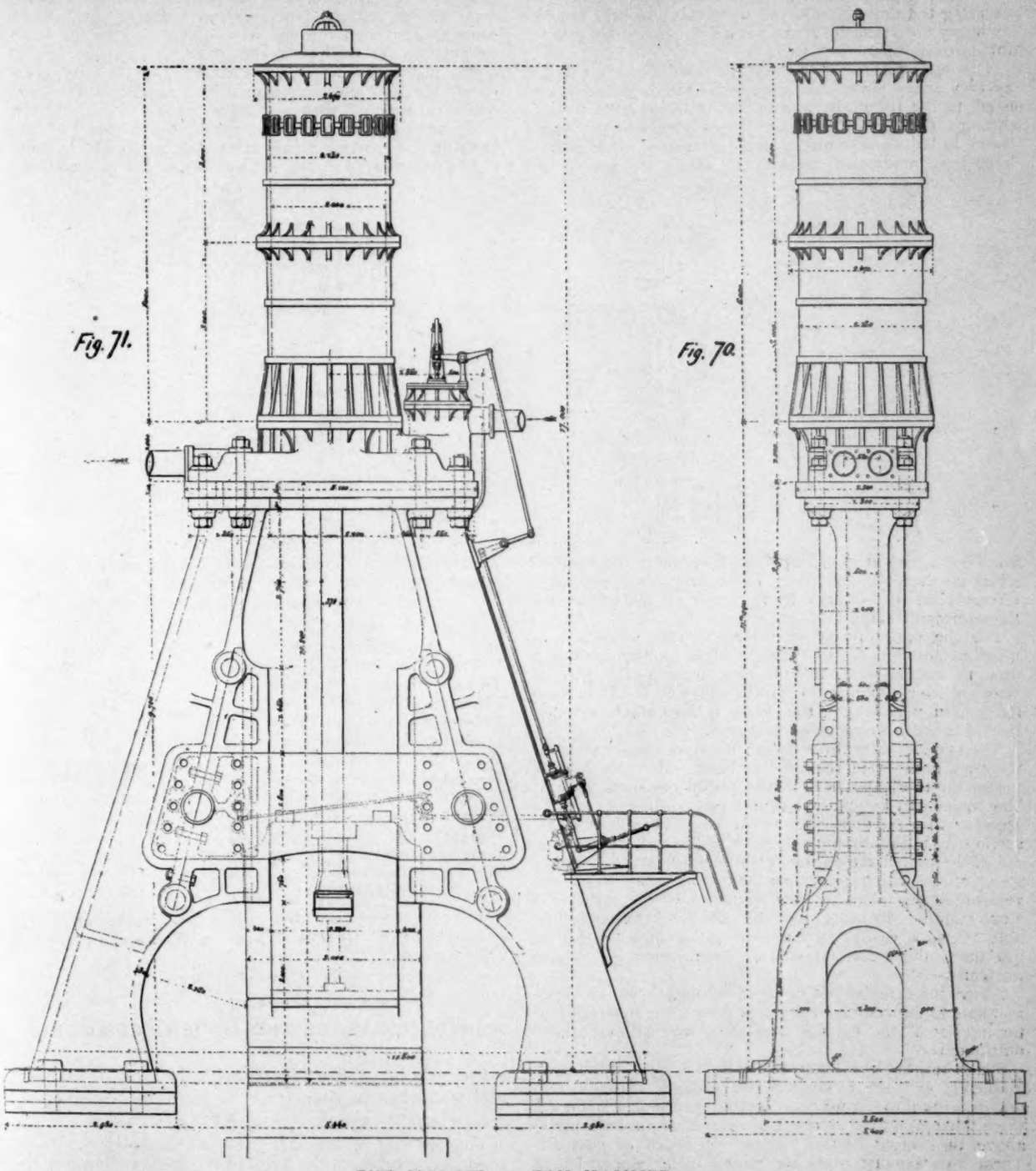
CHAPTER XXII.

THE MARREL 100-TON HAMMER.

Experience having shown that the 100-ton hammer at Creusot and the 80-ton hammer of St. Chamond were very useful for the forging of steel ingots up to two meters in diameter, the firm of Marrel Brothers have decided to build, and have begun the construction of, a single-acting

cannon of large caliber, shafts and cranks for large marine engines, and finally to manufacture steel armor-plates of great thickness.

The foundations of the hammer are placed on a rock, the surface of which has been dressed off perfectly level to receive a bed of cut-stone masonry, upon which is placed another bed of oak timbers strongly bolted together and intended to serve both as a support for the anvil-block,



THE MARREL 100-TON HAMMER.

100-ton hammer, which will be placed in their Etaings forge at Rive-de-Gier.

This hammer is represented in the accompanying illustration, fig. 70 being a side elevation, fig. 71 a front elevation, fig. 72 a plan, figs. 73, 74 and 75 showing the construction of the foundation and the anvil. It is intended to forge heavy pieces of steel, such as tubes and hoops for

which rests upon it, and as a spring to take up part of the shocks.

The anvil-block is composed of seven pieces arranged in four rows, the three lower ones being each in two parts joined together by rings or hoops put on hot; the upper piece, which receives the lower die, is in a single piece, its weight being 120 tons. The four rows are joined to-

gether by means of a number of keys, which make them in effect a solid block. The total weight of the anvil-block is 500 tons.

The frames are of cast iron. They rest upon seat-plates or shoes, also of cast iron, which are joined together by braces secured in grooves made in the shoes. These braces have a section of 160 square millimeters, and thus secure complete stiffness.

The frame proper, or legs, is of a single piece ; the part carrying the slides is adjusted upon this and kept in place by heavy bolts and by rings put on hot over lugs cast for this purpose upon each part.

The legs are braced at about the middle of their height by two heavy plates 100 mm. wide, fitted perfectly, and fixed to the frame by a number of large bolts passing through the legs. They are joined above to the upper frame by bolts of 150 mm. In the interior of the legs there have been made two recesses in which are placed two

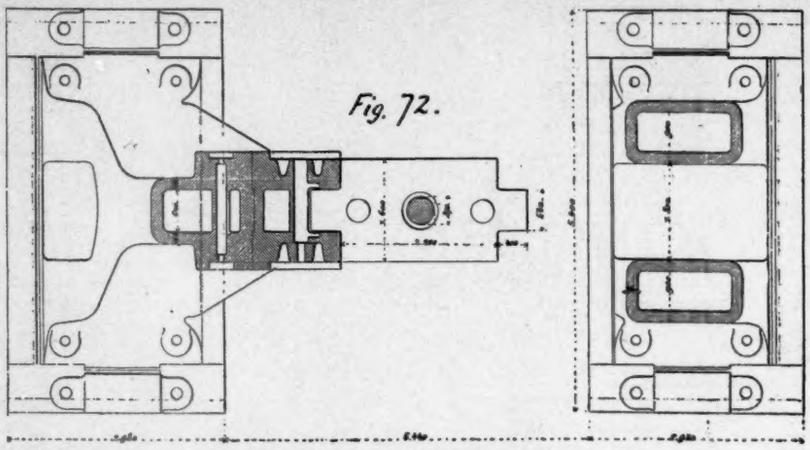


Fig. 72.

holding-catches or dogs, intended to support the hammer while the dies are changed. These are operated through intermediate bell-cranks by a foot-lever placed on the hammerman's stand.

For the upper frame or table, in order to reduce, as much as possible, the total height of the hammer, which is now 17 meters, MM. Marrel have used a plain plate of wrought iron 300 mm. in width, which certainly reduces the height very much ; this plate is also much stronger than if it had been made of cast iron.

The cylinder is in three parts ; the upper part carries at the top a number of rectangular holes, intended to allow the steam to escape in case the piston-rod should break. The lower part forms the steam-chest, and carries all the apparatus for the distribution of steam. The intermediate section is united by bolts to each of the two other parts. All of the parts have on the outside and near the flanges a series of ribs which strengthen them considerably and prevent breakage. The interior diameter of the cylinder is 2.000 meters. By using this large size the hammer will be able to work easily with a pressure as low as 3½ kilogrammes, the most unfavorable case which is likely to present itself.

Above the cylinder is a cover of wrought iron, having a manhole in the center, in order to permit the inspection of the interior of the cylinder and the piston without taking off the cover.

Steam reaches the hammer through a pipe 350 mm. in diameter, and the exhaust steam escapes through two others having the same total section and placed upon the same horizontal axis, in order to reduce, as we have noted above, the height of the hammer as much as possible. These two exhaust pipes are joined by an elbow, which then discharges into a pipe 500 mm. in diameter. The distribution of steam is made by a circular balanced valve 750 mm. in diameter. According to the formula which we have already given, this valve should be 850 mm. ; therefore, in order not to modify the total area of the steam exhaust openings, the height has been increased, and for the same reason the stroke of the piston-valve has been also increased.

In practice, it is quite impossible for a man to work a piston of 750 mm. with a stroke relatively large. MM. Marrel have therefore conceived the excellent idea of using an independent steam cylinder to operate the valve. This small engine, which is of the Farcot & Duclos type, is placed beneath the hammerman's stand, and the lever which works it is placed close to his hand, so that only a slight effort is sufficient to start it. In this position it is constantly under his eye, and he can handle the valves very easily. The steam for this independent cylinder is taken from the main steam pipe by a small copper pipe, and its exhaust is carried through a similar pipe into the main exhaust pipe of the hammer cylinder.

The piston-rod, which has a diameter of 370 mm., is securely fastened into the piston, which is of cast steel, and which is furnished with four segments.

We should note here that, having considered the difficulty of transporting pieces of such great weight as those of this hammer, MM. Marrel have established in their forge a Martin steel furnace and also cupolas, so that all the pieces could be cast upon the spot.

The principal dimensions of this hammer are as follows :

Diameter of cylinder	2.000	meters.
Stroke of hammer	5.100	meters.
Width of the hammer between the slides	2.200	meters.
Total width of the hammer	3.000	meters.
Diameter of the piston-valve	0.750	meter.
Diameter of the main steam pipe	0.350	meter.
Diameter of the exhaust pipe	0.350	meter.
Weight of striking mass	100,000	kilos.
Weight of the hammer-block	72,000	kilos.
Weight of the piston and rod	16,100	kilos.
Weight of the die and fittings	10,000	kilos.
Weight of the cylinder complete	52,000	kilos.
Weight of the frame	230,000	kilos.
Weight of the shoes	128,000	kilos.
Weight of the anvil-block	500,000	kilos.

The total weight of this immense tool, including all the parts above the stone and wood foundation, is 1,068,500 kilogrammes.

(TO BE CONTINUED.)

MARITIME CANALS AND MODERN COMMERCE.

IN a very interesting address made by Sir C. W. Wilson before the British Association at its recent meeting, he speaks as follows of the Suez and Panama Canals :

The opening of the Suez Canal, by changing the great commercial route, to the profit of the Mediterranean ports and to the injury of the Cape of Good Hope, has produced new changes in the relations between the East and the West, and England especially has felt the results. The changes referred to are three in number.

1. The raw materials and the manufactured products of the East arrive continually in greater quantity in the Mediterranean ports, going through the canal instead of, as formerly, to England to be distributed to other European countries. Odessa, Trieste, Venice, and Marseilles have

become centers of distribution for Southern and Central Europe, as Antwerp and Hamburg have for the North; the English merchants have lost the benefits which accrued to them from transporting and distributing the merchandise of the East in Europe. It is true that up to this time the transportation is still in great part in English hands, but should a war come this also would pass to other nations and would not easily be recovered. The industry of the Continent has been obliged, since the commencement of

2. The abandonment of the route by the Cape of Good Hope has led to the construction of steamers especially designed for Indian and Eastern commerce through the canal. On this line coaling stations are numerous, and navigation, except in the Bay of Biscay, is much more easy than on almost any other long voyage; the result is that ships have been built of an inferior type from a point of view of size, speed, strength, and seaworthiness. These ships built for the canal route are altogether unfit for the

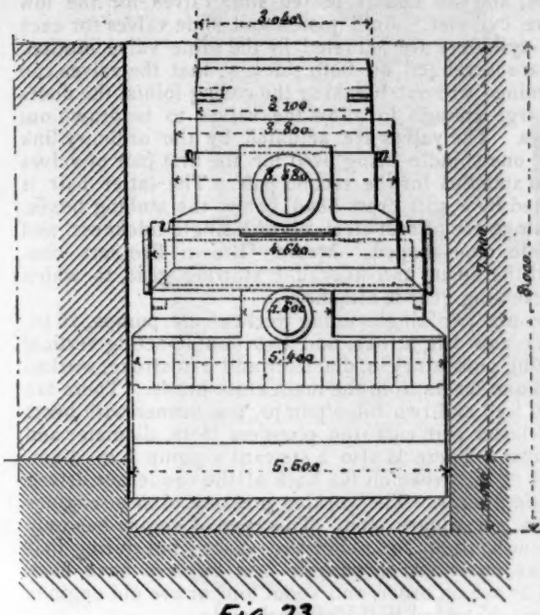


Fig. 73

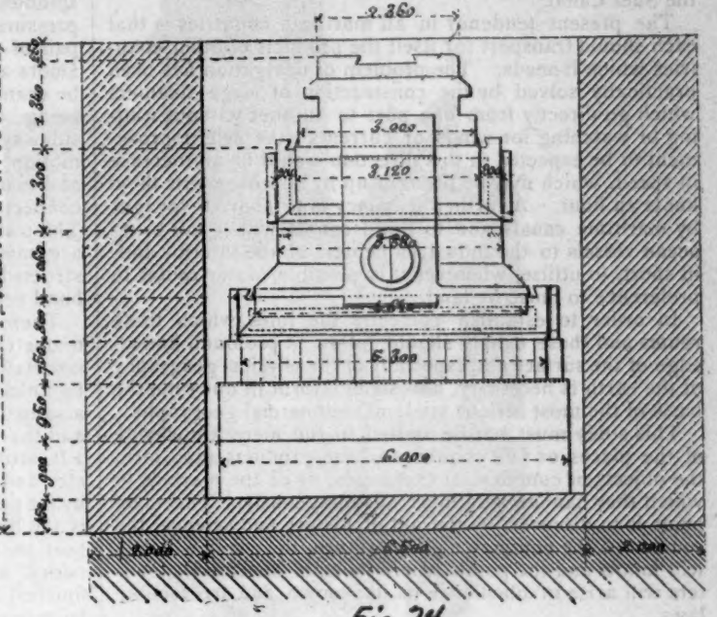


Fig. 74.

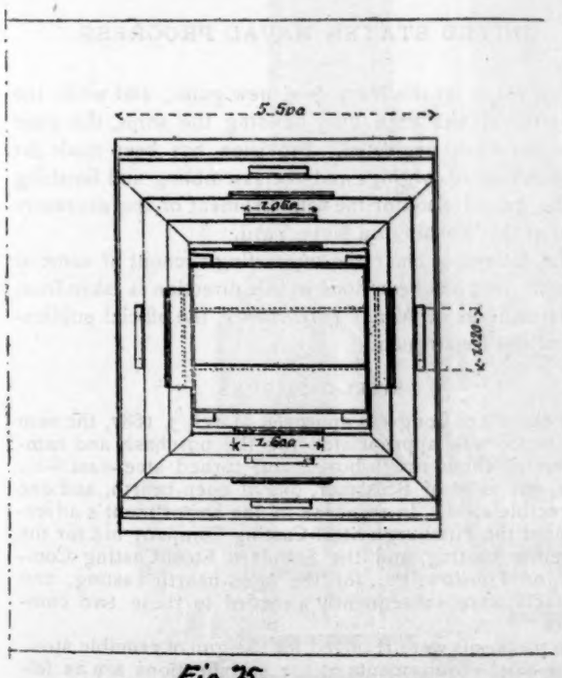


Fig. 75.

the present century, to support the position taken by England, and without doubt the control of the distribution of commerce which that country now holds will be lost sooner or later. The opening of the canal has hastened this time, to the injury of English manufactures and, in consequence, to the national wealth. England is gradually becoming less and less the warehouse of the world. It is feeling at present the working of that law under which a rearrangement of commercial centers must follow a change in commercial routes.

long voyage around the Cape, and should the canal be closed by war or accident they would be useless for the transportation of Eastern traffic. Since the canal has been deepened ships have been slightly improved, but they are still unfit to undertake the Cape voyage. Without the canal English commerce would have been enriched by the ownership of a large number of fine steamers, which would form a fleet invaluable in time of war, and it would not be, as it is now, in perpetual terror of being paralyzed by the closing of the canal.

3. Sir William Hunter has well shown that since the opening of the canal India has appeared in the English market in competition with the English manufacturer, and the development of that colony as an exporting country, for both manufactured goods and food products, must necessarily bring about transformations in English trade and production which will not take place without causing suffering and serious loss.

The commerce of India has increased very rapidly; the exports have risen from £57,000,000, the average figure for five years previous to 1874, to £88,000,000 in 1884. Wheat, which was formerly one of the most insignificant of the exports, has become one of the principal objects of commerce, and since 1873 the export of Indian grain has risen from 100,000 to 1,000,000 tons. It is impossible to predict to what limits this commerce in grain will extend; it is one forerunner of the objects which India can put in competition with European production upon the markets of the world.

The situation forced upon England by the opening of the canal is in some respects like that of Venice after the discovery of the route by the Cape of Good Hope, but there is a wide difference in the way in which these events have been accepted. Venice did not attempt to employ the Cape route, but, on the contrary, made every effort to prevent other countries from using it; England by a natural instinct opposed from the beginning the cutting of the Isthmus of Suez, but was the first to profit by it when the canal was opened to commerce, and it has so far struggled with success against its rivals to retain the carrying trade of the East.

It is quite natural to ask, What will be the results of the opening of the Panama Canal? This canal, when completed as a ship canal without locks, will establish closer commercial relations between the eastern and western coasts of the American Continent, and will benefit merchants by diminishing the distance and the cost of insurance. It will also receive a part of the commerce between the East and the West, but it will not produce changes at all to be compared to those following the construction of the Suez Canal.

The present tendency in all maritime countries is that each should transport for itself the products of other countries which it needs. The problem of navigation has been practically solved by the construction of large steamers which go directly from one port to another without waiting or watching for winds or currents; the sole improvement to be expected in this direction would be an increase in speed, which may be brought up by improvements to 30 knots an hour. A further tendency is to shorten voyages by maritime canals and to build canals which will bring ocean vessels to the industrial centers of the interior and, in short, to utilize, wherever it is possible, water routes in preference to those by land.

In order to establish correctly the lines which these routes and these canals should follow, a profound knowledge of the surface and especially of the physical geography of the earth is necessary, and should form in our time the basis of the most serious study of commercial geography.

This study must not be limited to the mere knowledge of the places or the countries whose products may form the objects of commercial exchanges, or of the markets in which they can be sold most advantageously. The chief point is to discover, by the aid of history and science, the sources of the commerce of the future, the roads which it will follow and the points where its chief distributing centers will arise in obedience to its known and irrevocable laws.

A profound study of the geography and physical structure of the globe; of the local distribution of minerals, vegetable products and different forms of animal life, not forgetting man; of the influence of locality on man and animals; of the climatic condition of different regions—all this is essential in order to solve the problems which are now presented to us. A country which wishes to maintain or improve its commercial position and influence must study these questions, and must prepare its people to fight courageously in the approaching combat for the commercial supremacy of the world. This fight will be a severe one, and the victory will certainly remain with those who best understand and bring into practice the proverb that "knowledge is power."

I may add that from the earliest historic days it has been an immutable law of commerce that when a country can no longer transport its merchandise in time of war, the traffic which it has carried will pass to some other nation. England is now the great carrying country of the world; when it can no longer defend its commerce it will share the fate of Venice, Spain, Portugal and Holland.

QUADRUPLE-EXPANSION MARINE ENGINES.

THE accompanying illustration, taken from *Industries*, represents the engines of the steamship *Buenos Ayres*, built by Denny Brothers, of Dumbarton, Scotland. These engines, of which there is an exquisite model at the Glasgow International Exhibition, are on the quadruple expansion tandem principle, patented by Mr. Walter Brock, Dumbarton, and the model is the work of Mr. David Carlaw, Glasgow. The four cylinders of the engines are 39 in., 46½ in., 64½ in., and 92 in. in diameter respectively, having a stroke of 5 ft. The cylinders are so arranged that the bottom of the high pressure cylinder forms the cover for the cylinder below, and the bottom of the third cylinder forms the cover for the low pressure cylinder, the whole being so constructed that the upper and lower cylinders can be removed at any time without disconnecting the valve-gear or breaking any connections except those between the cylinders. The two lower cylinders are bolted together, the space between them acting as a receiver for the exhaust from the second cylinder. The advantage of this design is its applicability to the conversion of ordinary two-cylinder compound engines into quadruple expansion. The piston rods have metallic packing, where they pass the bottom covers of the high pressure and third cylinders. There is one piston valve for the high-pressure cylinder, and one double ported slide valve for the second cylinder. For the third cylinder there are two piston valves on separate spindles, and two double ported slide valves for the low pressure cylinder. Both piston and slide valves for each pair of cylinders are actuated by the same valve motion. Doors are arranged on both sides, so that the valves can be examined without breaking the casing joints, the doors being large enough to allow the valves to be drawn out sideways. The valves are actuated by the ordinary link motion, one spindle being used for the first pair of valves and two spindles for the second pair. The latter pair is connected by a stiff cross-head below the stuffing-boxes. The pistons are of cast steel, all of a single thickness, and are made cone-shaped. Messrs. Brown Brothers constructed the steam and hydraulic starting gear, to which hand reversing gear is attached.

There are two single-acting vertical air pumps, 26 in. diameter and 2 ft. stroke, and two double-acting vertical circulating pumps 14½ in. diameter and 2 ft. stroke, worked by links and levers from the main cross-heads. There are also two feed and two bilge pumps, the former with brass and the latter with cast-iron plungers 5½ in. diameter and 2 ft. stroke. There is also a steward's pump 6 in. diameter and 12 in. stroke on the back of the condenser driven by the pump lever. The working pressure of these engines is 180 lbs. per square inch. This type of engine has only been manufactured for about two years; but during that period as many as 14 entirely new engines have been finished or are on order, and about four or five old engines have been converted to the new principle.

UNITED STATES NAVAL PROGRESS.

NEW ships for the Navy need new guns; and while the Department has been busy building the ships, the guns have not been neglected. Provision has been made for the purchase of forgings and the assembling and finishing of the guns; also for the establishment of the necessary plant at the Washington Navy Yard.

The following clear and interesting account of some of the work that has been done in this direction is taken from the latest issue of *Naval Intelligence*, the official publication of the Department:

STEEL-CAST GUNS.

By the act of Congress approved March 3, 1887, the sum of $20,400 was appropriated for the purchase and completion of three rough-bored and turned steel-cast 6-in. guns, one to be of Bessemer, one of open-hearth, and one of crucible steel. In response to the Department's advertisement the Pittsburgh Steel-Casting Company bid for the Bessemer casting, and the Standard Steel-Casting Company, of Thurlow, Pa., for the open-hearth casting, and contracts were subsequently awarded to these two companies.

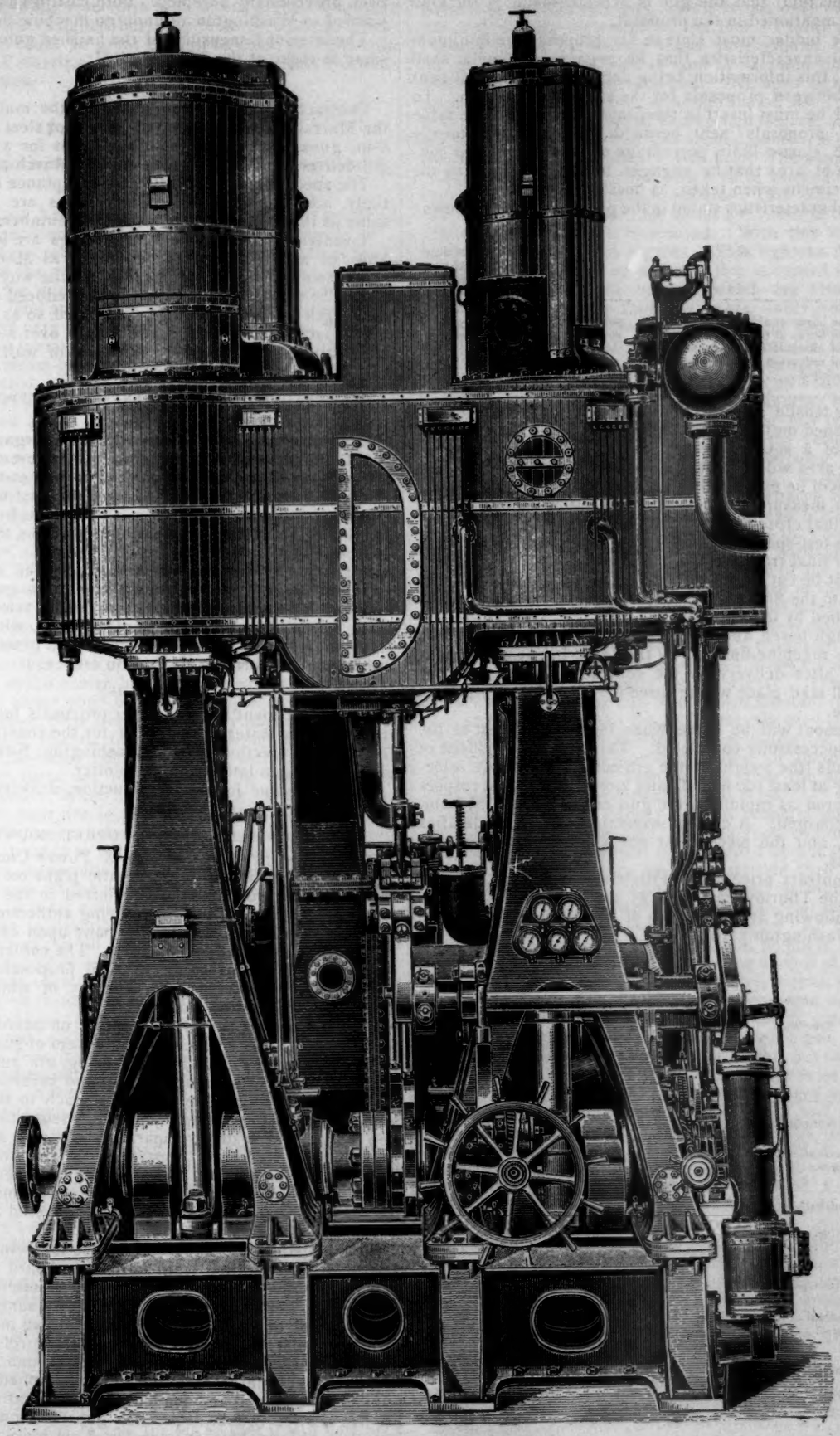
No proposals were received for the gun of crucible steel.

The chief requirements of the specifications are as follows:

"The castings from which these guns are to be made must be composed of steel of domestic manufacture, made from the best quality throughout the mass, and free from slag, seams, cracks, cavities, flaws, blow-holes, unsoundness, foreign substances, and all other defects affecting their resistance and value.

"The guns are to be each of one piece, except the breech-plug (and the trunnion-band, if so desired). They must be unforged.

"The Department is to have the right to satisfy itself



QUADRUPLE-EXPANSION MARINE ENGINE.

BUILT BY DENNY BROTHERS, DUMBARTON, SCOTLAND.

(by inspection) that the gun is actually made of the kind of steel mentioned in the proposal.

"The bidder must state in his proposal the minimum physical characteristics that he engages his metal shall possess, this information being necessary to an intelligent choice between proposals for the same kind of gun. To this end he must insert in the proper columns of the table in the 'proposals' sent herewith, the minimum tensile strength, elastic limit, percentage of elongation, and contraction of area that he engages to have exhibited by the test specimens when taken, as hereinafter provided."

The characteristics stated in the proposals are as follows :

	Pittsburgh Steel-Casting Co.	Standard Steel-Casting Co.
Stress to be borne at elastic limit .....pounds	40,000	40,000
Stress to be borne at tensile limit.....pounds	80,000	80,000
Per cent. of elongation to be shown.....	7	10
Per cent. of reduction of area to be shown.....	7	10
Weight, finished .....pounds	11,000	12,000

"The tensile strength and elastic limit of the steel will be reckoned on the original cross-section of the specimen (0.1963 of a square inch). The elongation and contraction of area will each be measured after fracture. The former will be expressed in per cent. of the original length between measuring points, and the latter in per cent. of the original cross-section.

"The test-specimen bars are to be taken from the casting after final treatment (at the expense of the contractor), and must be cut within the finished section prolonged, and as near to the finished gun as practicable (these points being verified by inspection).

"Rough-bored and turned castings that pass inspection shall be machine-finished by the Department within four months after delivery by the contractor. The statutory test shall take place within three months after completion as above.

"Payment will be made when the statutory test of the gun is successfully completed. This test is to consist of ten rounds (the weight of the projectile and muzzle velocity being at least 100 pounds and 2,000 ft., seconds, respectively), fired as rapidly as the gun can be loaded by hand and discharged. A critical inspection will be made after the test, and the piece must not exhibit any defects or weakness."

The contract price of the Pittsburgh casting is $3,300 ; that of the Thurlow casting is $5,300.

The following are the results of the physical tests made at the Washington yard :

Specimen.	Tensile Strength per Square Inch.	Elastic Limit per Square Inch.	Elongation after Fracture.	Reduction of Area after Fracture.
Pittsburgh Gun.	Pounds.	Pounds.	Per cent.	Per cent.
Muzzle :				
Longitudinal..... ...	81,185	40,464	18	21.26
Transverse.....	80,722	43,035	18.25	20.79
"	79,174	40,979	15.55	18.75
Breech :				
Longitudinal.....	88,973	51,693	9.15	10.89
"	89,686	51,693	10.35	13 88
Transverse.....	75,527	51,693	2.65	2.79
"	73,847	59,332	.60	1.60
"	73 236	55,258	1.85	4.35
Thurlow Gun.				
Muzzle :				
Longitudinal.	80,468	37,942	20.60	23.26
Transverse...	80,570	38,961	18.20	30.12
"	81.334	38,451	18.50	27.40
Breech :				
Longitudinal.....	80,519	38,961	19.55	24.31
"	80,977	38,451	19.10	27.40
Transverse..... ..	80,162	37,942	20.65	22.56
"	79,246	36,414	24.75	32.43
"	79,309	37,072	27.85	40 78

The deficiencies in the case of the Pittsburgh casting are marked, but they have been waived, and the piece has been provisionally accepted. Both castings have been forwarded to Washington to undergo machine finishing.

The interior dimensions of the finished guns will be the same as those of the 6-in., Mark II.

GUN FORGINGS.

Contracts have been concluded for the manufacture by the Midvale Steel Company of 32 sets of steel forgings for 6-in. guns, and one set of chase-hoops for a 10-in. gun. All deliveries are to be completed by March 2, 1889.

The specifications for tests and acceptance are substantially, and the physical property limits are exactly, the same as those published in last year's number.

Twenty-two sets of the 6-in. forgings are intended for guns of a new design to be known as Mark III. The chase-hoops of the new gun extend all the way to the muzzle. The diameter of the chamber is reduced to 7 in., and the length is correspondingly increased so as to preserve the capacity of Mark II. The length over all is 196 in. ; weight of gun, 11,000 lbs. ; thickness of wall over chamber, 6.75 in. ; at muzzle, 2.40 in.

OVERHEAD TRAVELING CRANES AND SUPPORTS FOR SAME.

Contracts have been made with the Morgan Engineering Company for the construction and erection at the Washington Navy Yard, of one 25-ton, one 40-ton, and one 110-ton overhead traveling crane ; the first-named to be ready for delivery, complete in all respects, by September 20, 1888 ; the second, by October 6, 1888 ; the third, by March 6, 1889.

A separate contract has been made for the construction and finishing of the iron frame for a 12-in. gun-shop and supports for the 110-ton crane within the same ; all to be ready for delivery, complete in all respects, within 90 days from May 1, 1888. The same contract provides for the erection of supports for the 40-ton cranes.

GUN LATHES.

The Department has called for proposals for furnishing the necessary material and labor for the construction, delivery, and erection at the Washington Navy Yard, of eleven 6-in. gun lathes and one slotter.

Also, the same for the construction, delivery, and erection of sixteen 16-in. gun lathes.

PROPOSED MONITOR TURRET MOUNT.

The Pneumatic Gun Carriage & Power Company having proposed to install a pneumatic plant on one of the monitors, the proposition was referred to the Pneumatic Gun Carriage Board, the Board being authorized to confer with representatives of the Company upon certain terms that were not deemed satisfactory. The conference led to certain modifications of the original proposals, and, ultimately, to a contract, signed April 25, of which the following are the leading features :

The company to supply, and set up on board the monitor *Terror*, at Boston, Mass., for the sum of $228,750 : (1) All the pneumatic machinery, gearing, air compressors, etc., necessary for steering the ship and revolving the turrets ; (2) four 10-in. gun carriages, each to be provided with pneumatic elevating cylinders, pneumatic ammunition hoists and loading apparatus, etc. ; (3) a complete pneumatic refrigerating apparatus. All of the above to be ready for installation within 18 months from the date of contract, and to be ready for test within six months from the time thereafter that the vessel is delivered to the contractors in condition to receive it.

On completion, the plant to stand the following test : (1) The helm to be shifted from hard-a-starboard to hard-a-port (or the reverse) in 16 seconds, and as often as once a minute ; (2) both turrets to be turned at the same time and at the rate of one complete revolution in two minutes, the turrets to be at all times under complete control in accordance with the requirements of an efficient manœuvring of the guns ; (3) the ammunition to be supplied, and the guns to be sponged and loaded with sufficient rapidity to fire five service rounds from each gun (20 rounds in all), in volleys of four shots, at intervals of not more than three minutes between consecutive volleys. The system is to perform the above operations simultaneously. The initial

air pressure in the reservoirs is to be not greater than that which they are designed normally to carry, and the terminal pressure must be great enough to carry on efficiently the work of steering, revolving the turrets, and manœuvring the guns.

PETROLEUM FUEL.

(Paper read before the National Electric Light Association by S. S. Leonard, of Minneapolis.)

PETROLEUM has been used as a fuel for a number of years. Experiments to determine its practicability as a fuel have been creating a great deal of attention from those interested in the matter for the last 20 years, and it is now occupying the minds of some of our ablest engineers and inventors. The successful use of oil as a fuel has, however, been of very recent date, yet so rapidly has it grown in favor that to-day it is regarded as a strong competitor of coal for steam-generating purposes or where heat and fire are wanted. It was with a great many knowing winks and nods of the head from the engineers and firemen, who laughed at the idea of making steam by the use of oil, that the writer attempted the use of petroleum as a fuel. Of course it would not work, and it did not work. Why? Because those who were using it did not want it to, as they were afraid some one would lose his job. We had seen enough of its workings to satisfy ourselves that it could be made a success, and the result is that to-day we are saving from 20 to 25 per cent. on the cost of the fuel, and 50 per cent. in labor, and these same men who laughed so hard on the start at our attempt to use oil would feel that this world was a poor place to live in were we to return to the use of coal, for not only their hearts but their backs would certainly be broken.

Its advantages over other fuels are many. In the first place, it is much easier handled; a steadier fire is easily maintained under your boilers, consequently the steam is kept at a more even pressure—a very important thing in the running of electric lights; there is no opening of furnace doors, allowing cold air to come in contact with the boilers, and there are no impurities in the oil such as abound in coal. When through with it, by a simple turn of the wrist your fire is put out, and your ash-pits are as clean as they were before the fire was started. In less time than it takes to tell it you can start the fire. It is only rivaled in handling by natural gas, and even then, unless we have all the modern appliances for the handling of this gas, it is far easier to manipulate.

Permit me to describe the arrangements for the handling and use of this oil put in under the supervision of the writer. The oil is received in tank cars holding from 90 to 150 barrels each (42 gals. to a bbl.). From these cars it is drawn off through a valve in the bottom of the car to a storage tank or tanks, there being two of them, holding about 320 bbls. each. These are placed underground, so that the oil runs from the car into them by gravity; care should be taken not to spill the oil or stir it up more than is necessary, as the odor from it is fully equal in strength to that of new-mown hay, if not quite as agreeable. To prevent the stirring up of the oil, the supply pipes entering through the top of the tanks run nearly to the bottom, so that the tanks are practically filled from the bottom. In the top of each tank are manholes and a vent pipe; this latter is extended above the tanks a short distance. These tanks, which are boiler-shaped, are placed end to end, with a space of about 8 ft. between them. This gives room to get at the various pipes. They are joined together at the bottom by a pipe, which also connects with the supply pipe running to the boiler-room. Then in the bottom of each is a drain pipe which will admit of cleaning them out whenever necessary. There is also a gauge glass in the end of each to show how much, if any, water is in them; there is also a gauge made by a copper float, which indicates the amount of oil in each tank. In cold weather a small steam coil is inserted in the tank car around the mouth of the valve to heat the oil, so that it will flow readily, for when the thermometer gets in the vicinity of 30 or 40 below, the oil is apt to be a little thick. Care should be taken not to heat the oil too much, for when hot it generates considerable gas, which is not only very odorous, but is really the cream of the fuel. I think it an advantage to have the storage tanks underground, there being less danger from them in case of fire, and during the winter the oil is less likely to chill. An open light should never be used near them; although the oil itself is really hard to ignite unless heated to a certain degree, still there is apt to be more or less gas around, which is quite explosive if brought in contact with fire. The supply pipes to the furnaces are provided with a valve where they enter each tank, also one in the fire-room. This pipe, a 2½-in. one, is enlarged to a 6-in. for about 4 ft., and in this 6-in. pipe a small steam pipe is inserted. With this the oil is heated from 130 to 140 degrees. This lightens it so that it burns more readily, or, I should say, is turned into gas.

We now come to the burners, which are also fed by gravity, as the storage tanks, although underground, are still higher than the furnaces. One might suppose that, owing to the recent introduction of petroleum as a fuel, some difficulty might be experienced in obtaining a burner, but their name is legion; and they are as numerous as electric light systems, and like them in another respect—each man's is the best. Our experience has been that the more simple the burner the better the result. One that thoroughly vaporizes the oil before burning it is, we think, preferable to one that burns the oil. In the former there can possibly be no waste. In furnaces where we have been using this kind of a burner the bricks are as clean as they were the day they were put in. Steam and hot air are the other ingredients that are used in connection with the oil, and an abundant supply of the latter we have found adds very much to the efficiency of the fire.

Regarding the proper settings, circumstances will determine that to a certain extent. An excellent plan is given by the Standard Oil Company in their pamphlet, "Oil as a Fuel." This we have adopted with a few modifications which we found necessary by experience. There is no doubt that a hotter fire can be obtained from oil than from coal or wood, and when the oil is properly used the smoke nuisance is solved which has been agitating the minds of the people of some of our large cities, for there is not a particle of smoke to be seen issuing from the stack, not even when everything is running full blast.

A word as to its danger: When properly put in and handled with ordinary care, or when good common-sense is used in the employment of this oil, I do not see why it should be any more apt to cause trouble than coal, although the insurance companies insist on higher rates when used. I think it more from ignorance of the subject than from there being any more danger. At the same time I am willing to admit that it could be put in and used in such a way as to greatly increase the danger of fire. So might your house be wired for electric lights, piped for gas, or a kerosene lamp hung on your gasolene stove filled in such a manner that the fire risk is much greater than with your neighbor, who uses electric lights, gas, kerosene or gasolene the same as you do, but has his put in properly and handles it as it should be handled. As to its economy over coal, I have already mentioned that there was a saving of from 20 to 25 per cent. on the cost of fuel, and from 40 to 50 per cent. in labor. From tests recently made by us, the following figures were obtained: 111.34 H. P., running six hours, used 250 gals. of oil, costing $5.50, or at the rate of 70 cents per 100 H. P. per hour; 104.8 H. P., running six hours, used 3,461 lbs. of coal, costing $5.45, or at the rate of 86 cents per 100 H. P. per hour. Another test gave the following figures: 96.45 H. P., running eight hours, used 4,014.75 lbs. of coal, costing $6.32, or 80 cents per 100 H. P. per hour; 115.54 H. P., running seven hours, used 233 gals. of oil, costing $5.05, or 62 cents per 100 H. P. per hour. On the above figures, oil is from 17 to 32 per cent. cheaper than coal. The highest evaporation made with oil was 14.8 lbs. of water per lb. of oil, with feed water at 103, and with coal 5.38 lbs. of water per lb. of coal, feed water at 103. The coal used was a good grade of Illinois lump, costing $3.15 per ton, but which is usually worth $3.25.

In the matter of labor one man can easily attend from seven to ten 150-H. P. boilers, and then have less to do than he would were he firing one boiler with coal. After

a week's run with oil your boiler flues are much cleaner than they would be from the use of bituminous coal for one night, especially Western coal. Your fire-room can be kept as clean as your dynamo-room. There being no ashes you are saved the expense of handling them as well as the dirt, and the former is no small matter where some 20 tons of coal are being used every 24 hours. I might say that the above tests were made during a part of the day's run, and it is our opinion that a more favorable showing could be made with the oil where a larger number of boilers are in use. It seems to work better with a good fire than where a small fire is sufficient.

ELECTRIC SUBWAYS IN NEW YORK.

(Paper read before the National Telephone Exchange by L. F. Beckwith.)

IN the following statement I have recorded a few data relating to the construction of electrical subways in the city of New York which may be of interest. The work was commenced in the latter part of 1886, and has been carried on since, with but slight interruption each year during the season favorable to out-of-door operations. The subways as laid out and built have been authorized and approved from time to time by the Board of Electrical Control, and the Consolidated Telegraph & Electrical Subway Company has been directed by the Board to construct them under its contract with the latter. The execution of the work has been intrusted by the above company to its sub-contractor, the Phœnix Construction Company, which has charge of all subway construction in this city.

The subways have been designed and laid out to meet the main requirements of the chief connecting or trunk lines of the various electrical companies so far as they could be ascertained, and so far as they could be conveniently grouped together. The principle of keeping the high tension electric currents for arc lighting and power in subways on one side of each street, and the low tension electric currents for telephone, telegraph, and other purposes in subways on the opposite side of the street, has been laid down and so far adhered to. The question of distribution from the conduits has been wisely left by the Board of Electrical Control to the various electrical companies to express their preference for the method best suited to their special systems. This the companies have been repeatedly invited to do, and while some have responded, and their methods of distribution having been approved as reasonable and feasible, they have been accommodated as rapidly as possible; other companies have held aloof and refrained from action, apparently wasting precious time and neglecting to occupy and secure their commercial field and districts.

The subways built, except the Edison, are all on the "drawing in" system, which provides a group of tubes or ducts extending from one manhole to another, admitting of the drawing in and out of the electrical cables, and affording convenient access from the street. Different systems of grouping the ducts in the trench, and different materials have been employed, consideration being held of the importance of the line, the question of cost, the durability, tightness against water and gas, etc. Experience has shown us that a main conduit consisting of separate pipes which can be crowded or curved or kept apart is the best adapted to overcome the numerous obstructions met with underground, and frequently diminishes the trenching necessary. Screw-jointed, asphalted wrought-iron pipe laid preferably in hydraulic cement concrete present the greatest tightness of duct against gas and water, united with the greatest strength. The cement pipe and creosoted wood tubes present also features of great merit and adaptability. A special feature of New York subway difficulties is the steam-heating underground system, of which the leaks in certain localities greatly interfere with the ducts and cables, precluding the use in such places of materials of construction softening or melting at about 160° to 200° F. In the case of long telephone lines, the desirability of comparing non-metallic and metallic ducts in respect to their influence on low tension currents has also been kept in view. A continuous line of telephone and telegraph subway is now completed about seven miles long, and the above comparison can be made on five to six miles of this length.

The endeavor has been to provide a subway construction that will be most durable, and that will give the best mechanical protection to the cables against injury from settlement of the ground, heat, water, gases, etc. The solution of the electrical question of underground working is one that relates to the manufacture of suitably insulated cables, and belongs properly within the province of the electrical companies.

The work accomplished up to September, 1888, is shown in the accompanying table:

Dorsett ducts, coal tar concrete	235,837	ft.
Zinc tubes laid in hydraulic cement concrete	68,883	"
Creosoted wood tubes	167,175	"
Cement pipe laid in hydraulic cement concrete	216,626	"
Iron pipe laid in asphaltic concrete	131,284	"
Iron pipe laid in hydraulic cement concrete	1,423,722	"
Iron distributing pipe	23,301	"
Edison iron tubes	222,794	"
Grand total length of single ducts	2,489,622	ft.
Grand total length of single ducts	472	miles.
Grand total length of trenches	37	"
Number of manholes	523	
Total length of telephone and telegraph ducts	376	miles.
Total length of electric light ducts	96	"
Length of telephone and telegraph trenches	19½	"
Length of special electric light trenches	17⅜	"

Besides the above there is still about three-quarters of a million feet of single duct for telephone, telegraph, and electric light purposes, authorized by the Board of Electrical Control to be built, that remains to be constructed, besides contemplated lines.

The standard size adopted for telephone ducts is 2½ in. clear inside diameter, corresponding to a capacity of 100 wires, or 50 conductors in metallic circuit grouped in a lead-covered cable. The chief portion of electric light ducts other than Edison ducts are 3 in. clear inside diameter. The manholes are all of brick laid in cement mortar with 8 to 12-in. walls and concrete bottoms. They vary greatly in form, and are from 8 × 12 ft. to 4 × 4 ft. 6 in. in size, and from 6 to 12 ft. deep. The street casting used has a double cover; the inner cover and rubber gasket are held down by a wrought-iron cross bar, a bolt and padlock. The covers are practically tight against water.

The systems of distribution in use are as follows: For telegraph purposes, an iron pipe from the manhole connects underground with a building or with the foot of a pole. For telephone purposes the above method is used, and also in connection therewith a pipe running up the face of the building to the roof, where, from a fixture, the cable is divided for distribution on the block and surrounding blocks. Sometimes the pipe is carried up through an elevator or ventilating shaft. In addition to the above, in the down-town districts, and along Broadway to Union Square, an iron 3-in. pipe is laid in the trench above the subway, and provided at intervals of about 50 ft. with malleable iron circular distributing or service boxes with screw covers 12 in. in diameter, with side outlets through which a cable can be conducted by a service-pipe into the buildings.

For electric light distribution the Edison Company have their special system laid. The Johnstone cast-iron distributing conduit, with six ducts and flush boxes, has been authorized to be laid in Broadway, from 14th Street to 35th Street, for purposes of electric light distribution, and will provide all the necessary facilities for this district.

Up to August 27, 1888, there were 3,567 miles of wire laid in the subways by the Metropolitan Telephone & Telegraph Company. This company has laid a 100-wire lead-covered Patterson cable from Whitehall Street to 58th Street, a distance of about six miles. This cable is believed to be the longest of this size in existence underground. The Western Union Company has about 100 miles of wire underground, and the Edison Company about 126 miles. The Brush Electric Illuminating Company is putting an 8-conductor Standard cable in the Broadway conduit from 14th Street to 35th Street, a distance of one mile, making eight miles of electric arc-light wire. Other applications for space in the subways and for the construction of additional electric light lines are pending.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

(Copyright, 1887, by M. N. Forney.)

(Continued from page 473.)

CHAPTER XVI.—*(Continued.)*

THE RUNNING GEAR.

QUESTION 480. *Why are the ends g', g' of the springs attached to the lever* A A?*

Answer. Because if there is a spring for every axle and the hangers are fastened to the frames, then evidently the locomotive has as many points of support as it has axle-boxes. Every shock from the rails is transferred through the wheel and the axle to the nearest axle-box and the spring belonging to it, and the latter must be made strong enough to receive and dispose of the whole of it. If the adjacent hangers, g', g', fig. 286, of the adjoining springs, B and B', are connected by an equalizing lever, $A\ A$, which turns on the fixed point C, then the shock which affects one wheel will be transferred first to the corresponding spring. From this spring a part of the shock will be transferred to the frame by the hanger g, and a part by the hanger g' to the equalizer, which will transfer the pressure to the adjoining spring B'. If by some unevenness of the road or a powerful oscillation of the locomotive a spring is momentarily burdened, the equalizer thus causes the next wheel to receive part of this load.

The advantages of this arrangement are evident: since the springs have to receive only a part of the shocks, they can be made less strong and therefore more flexible. The danger of running off the track and that of breaking axles, springs, and hangers, is therefore reduced by the use of equalizing levers.

QUESTION 481. *How are the equalizing levers constructed?*

Answer. They are made of wrought iron and are supported in the center by a fulcrum, C, fig. 286, which is fastened to the frame or boiler or both. The spring-hangers g', g' are usually attached to the levers by eyes and keys. Sometimes eyes are made in the lever, as shown in fig. 286, and the hanger is inserted into the eye and held either with a key, as shown, or else with projections which are forged on the hanger below the lever. In other cases the hangers are made with an eye which embraces the end of the lever.

QUESTION 482. *How is the distribution of weight of the engine affected by the equalizing levers?*

Answer. The effect of the equalizing levers is to distribute the weight equally on all the driving-wheels. This is apparent if it is observed that the weight suspended from each of the spring-hangers of each spring in fig. 286 must be the same; for if the weights in the two hangers g' and g' were unequal, then the end of the spring which supports the heaviest weight would be drawn down until the pressure was equalized. If the weights suspended from the two hangers g' and g' attached to the equalizing lever were unequal, then the one supporting the greatest load would draw up its end of the equalizer until the weights were again in equilibrium.

Another effect of the equalizing levers is that each side of the locomotive is supported in such a way that the action is the same as it would be if it was supported on one point. If, for example, we have a heavy beam, say a piece of timber like that shown by $A\ B$, fig. 302, suspended at one point, C, in its center, to the middle, a, of a long spring, $D\ E$, the ends of which rest on two supports, F and G, it is evident that if the point of suspension is at the middle, C, of the beam, and a of the spring, the weight of the beam will rest equally on the two supports F and G, and that the ends of the beam can move up or down or vibrate about the point of suspension, C, without affecting the distribution of weight on the supports F and G. If, now, the timber is suspended from three points, its middle, C, and two ends, A and B, as shown in fig. 303, the ends A and B being attached to the ends of the springs $b\ c$ and $d\ e$, the latter resting on the supports F and G, and connected at their

Fig. 285.

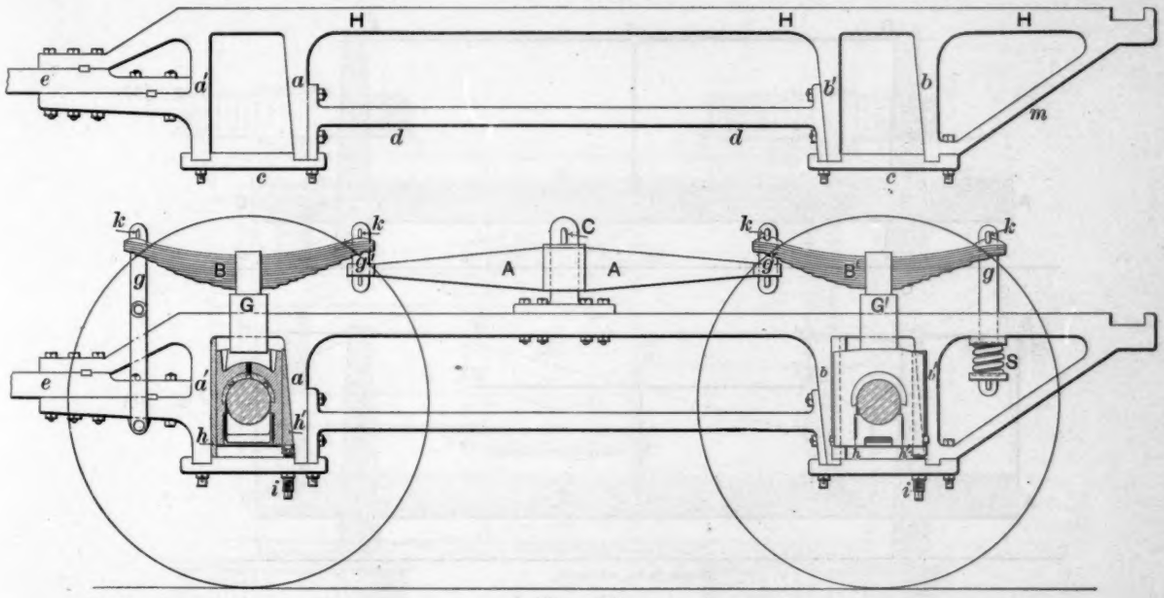


Fig. 286.

opposite ends to an equalizer, $f\ g$, whose fulcrum is at a, it is evident that each of the end hangers, $b\ A$ and $e\ B$, must support one-half of that part of the weight of the timber between it and the middle, and that the center hanger, $a\ C$, must support one-half the weight between the middle and the two ends. Thus the hanger $b\ A$ must support one-half the weight of the timber between A and C, and $e\ B$ must support one-half of that between B and C; in other words, the end hangers would each sustain one-fourth of the weight of the timber and the middle one-half of its weight. If the weight of the timber is 1,000 lbs., the end hangers would each sustain 250 and the middle one 500 lbs. The weight of the middle of the timber is hung on the equalizer $f\ g$, and one-half, or 250 lbs., of it is thus transferred to each of its ends, f and g, and thence to the hangers $f\ c$ and $g\ d$, and thus to the springs, so that the ends c and d of the springs each sustains a weight of 250 lbs.; therefore, as the opposite ends also sustain the same weight, it is evident that each of the springs bears a total load of 500 lbs., or one-half of the weight of the timber. If the ends of a timber supported as shown in fig. 303 are moved up or down about the center point of suspension, it is evident that the distribution of weight would not be affected any more than it was in fig. 302 by a similar movement, because if the ends of the timber move as shown by the dotted lines around the center point of suspension, C, the end A will ascend as much as B descends. The same thing is true of the ends b and e of the springs and of their opposite ends c and d, and also of the ends of the equalizer, so that when the timber, springs and equalizer are in the position shown by the dotted lines, it is in equilibrium, just as it was when the timber was horizontal; and therefore the weight on the supports is the same in both cases, thus showing that the load $A\ B$ can move about the center of

* This lever is called an *equalizing lever* or *beam*, or, more briefly, an *equalizer*.

suspension when supported as shown in fig. 303 as freely as it can if arranged as shown in fig. 302. It therefore follows that in the distribution of the weight of each side of the locomotive on the wheels and on the track, it may be regarded the same as though it was supported at one point, which is the fulcrum of the equalizing-lever.

QUESTION 483. *What advantage results from supporting the weight of the back part of the locomotive on two points?*

Answer. If the back part of the locomotive rests on only two points and the front end on the center of the truck, then the whole weight of the engine will be sustained on three points. Now, it is a well-known fact that any tripod, like that on which an engineer's level is mounted, or a three-legged stool, will adjust itself to any surface, however uneven, and stand firmly in any position; whereas if there are more than three points of support, if they are all of the same length, the surface on which they rest must be a plane, otherwise some of them will not touch. All railroad tracks have inequalities of surface, and therefore it is of the utmost importance that a locomotive should be able to adjust itself on its points of support to any unevenness of the track on which it must run. This is possible only when the weight rests on three points of support.

QUESTION 484. *How is the truck constructed?*

Answer. As has already been explained, trucks usually have two pairs of wheels.* These are attached to a frame, 75, 75, 302, 303, 304, 305, 306, 307, 308, 309, which are fastened to the sides of the truck-frame. The engravings show what is called a *swing-motion* truck. In this the center plate is suspended from the transverse bars by links *L L' L L'*, so that it can swing or oscillate transversely to the *rails*. These links are suspended from the pins *l l, l l*, which pass through the bars *m m, m m*, and the center casting or center-plate *H* rests on other pins *l' l'*, which pass through the lower ends of the links. The dotted lines *L a, L b* and the arcs *a b, a b* show how the center plate *H* swings on the links. The center-pin *S* sometimes has a key underneath the center-plate. This key is intended to prevent the engine from "jumping" off of the truck on a rough track or in case of accident. The annular groove in the top of the center-plate and the projection which fits into it are intended to receive the strain which otherwise would bear against the center-pin and would be liable to break or bend it.

From this description it will be seen that while the truck-frame rests on two points, *k* and *k*, the weight of the engine is supported by the center-plate of the truck. As the back part of the engine rests on substantially the centers of the two equalizers, it will be seen that this distribution of the weight fulfills the conditions of the tripod, or, as it has been called, the "*three-legged principle.*"

QUESTION 485. *How are "pony" or Bissell* trucks with a single pair of wheels constructed?*

Answer. A plan of such a truck, *g s h*, with its details omitted, is shown in fig. 276. Figs. 307, 308 and 309 represent a truck of this kind with all its parts; 307 is a longitudinal section, 308 a plan, and 309 transverse section. It consists of a rectangular frame, *a b*, fig. 276, to which the axles are attached. As explained in answer to Question 436, it also has an A-shaped frame, which is bolted to the back part of the rectangular frame. The apex of this A-shaped part is connected to the main frame of the locomotive by a pin *s*, about which the truck can turn. The rectangular frame is indicated by the letters *C D E F* in figs. 307, 308, and 309, and the A-shaped portion by the letters *r s t*. Such trucks have swing-bolsters, *H*, similar to those used on four-wheeled trucks. They are suspended from links *L L'*, whose lower ends swing in arch of circles indicated by the dotted lines *a b*.

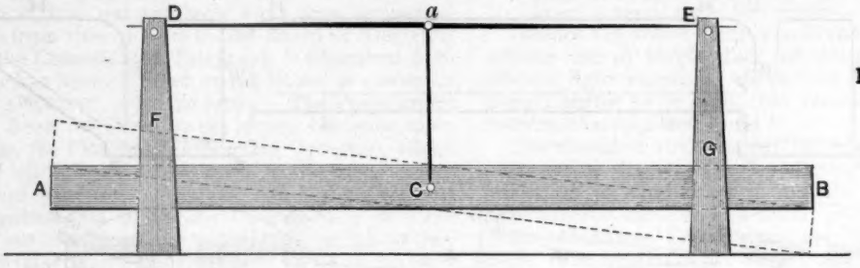


Fig. 302.

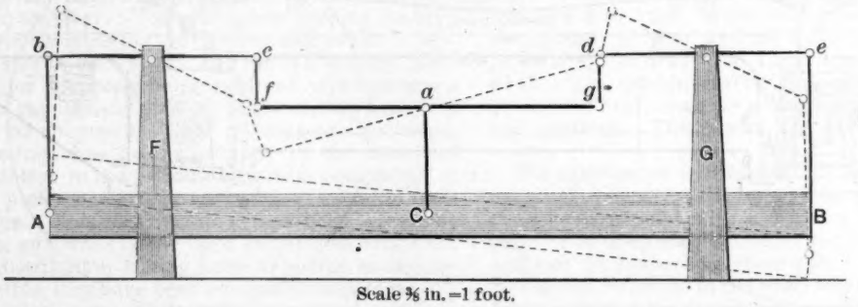


Fig. 303.

Scale ⅜ in. = 1 foot.

QUESTION 486. *How are the king-bolts of pony trucks arranged?*

Answer. The front king-bolt, *K K*, figs. 307, 308 and 309, is held in a casting *B B*, which is bolted to the engine frame, and bears on the swing-bolster *H*. In some pony trucks this king-bolt is a solid bolt or pin, like that shown in figs. 299 to 301. In other cases it has been found desirable to connect trucks of this kind with the front driving-wheels by an equalizing lever, and the king-bolt is then made hollow, as shown in figs. 307, 308 and 309.

QUESTION 487. *Why are pony trucks connected to the driving-wheels by equalizing levers?*

Answer. This is done for very much the same reason that driving-wheels are connected together in this way, as was explained in answer to Question 480. The connection of a pony truck with the driving-wheels of a locomotive is the invention

Plates III, IV, and V. The axles have boxes called *truck-boxes*, and brass bearings similar to those used on the driving-axles. These boxes work in jaws, also similar to those on the main engine frame, excepting that they have no attachment to prevent them from being worn by the motion of the boxes up and down in the jaws. Fig. 304 is a longitudinal section, fig. 305 a plan, and fig. 306 a transverse section † of a truck. The frame *C D E F*, fig. 305, shown also at *h' h'*, figs. 304 and 306, is of rectangular form, and is forged in one piece. The legs *f f* which form the jaws for the boxes are bolted to the frame as shown in fig. 304. To the lower end of these legs a brace, *g g g*, is bolted, which ties them together. On each side of the truck one spring, *M M*, is placed under the frame and in the reverse or inverted position to that of the driving-springs shown in fig. 286. A pair of equalizing levers, *G G*, is placed on each side of the truck, one of them on the inside of the frame and the other on the outside, as shown in the plan. The ends of these equalizers rest on the top of the truck-boxes, and the springs are attached to the levers at *i i* by the hangers *j j*. The truck-frame rests on the top of the spring-strap, *N*. It is evident that this arrangement of spring and equalizer operates in the same way as that employed for the driving-wheels in distributing the weight on each of the wheels, and that the truck-frame is supported on two points, *k, k*, figs. 305 and 306. The weight of the front end of the engine rests on a cast-iron *center-plate, H*. This is sometimes bolted rigidly to transverse bars, *m m, m m*, figs. 305 and 306, which are fastened to the sides of the truck-frame. The engrav-

* In some rare cases three pairs of wheels are employed for locomotive trucks. Six-wheeled trucks are very commonly used under passenger cars.

† The sections are both shown through the center of the truck.

* So named after their inventor, Levi Bissell.

of the late William S. Hudson, who patented the plan in 1864. In his specification he said that "in practice irregularities more or less serious occur at nearly every joint or junction of the ends of the rails, and at certain points in a railroad track, as in passing switches and across tracks, and especially in passing over small obstacles or defects in the road, the inequality in the load which is thrown upon the several wheels becomes very great unless, in addition to the rise of the springs, provision is made by introducing equalizing levers in some manner to induce a unity of action between each pair of wheels and some other pair."

front driving-axle, and *d d d* represents one-half of the periphery of one of the front driving-wheels, and *e e* one-half of the driving-wheel springs. The two ends of a transverse equalizing lever, *h i j*, are connected by hangers *k k* to the front ends of the driving-wheel springs, and the back end *Q* of the lever *O P Q* is suspended to the center *i* of the lever *h i j* by a hanger *m*. It is obvious that if one or both of the front driving-wheels should roll over any object, or a high place in the track, so as to be raised up and thus compress one or both of the springs *d d*, that this action would produce an upward tension on the transverse lever *h i j* the hanger *e* and the back end *Q* of the

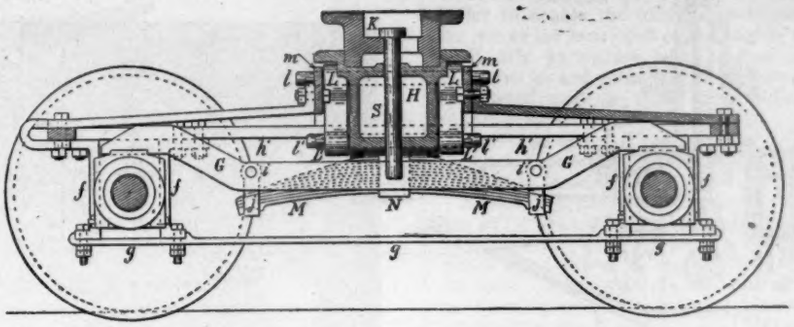


Fig. 304.

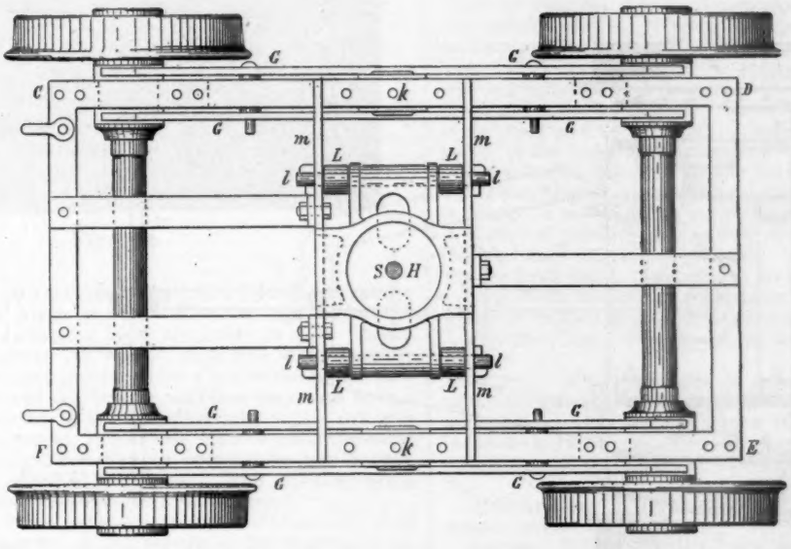


Fig. 305.

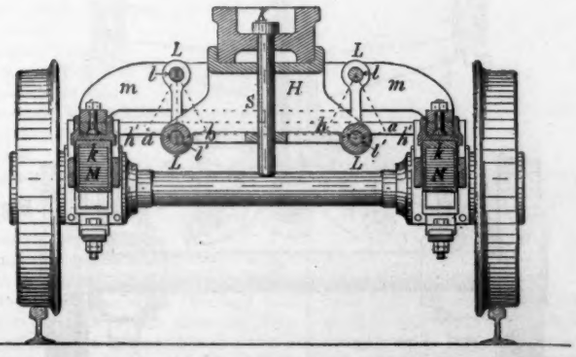


Fig. 306.

QUESTION 488. *How are equalizing levers arranged to connect pony trucks with the driving-axles of locomotives?*

Answer. Usually one equalizing lever, *O P Q*, is placed on the middle of the engine instead of using one on each side, as is the ordinary practice with driving-wheels. This lever has a fulcrum at *P*. The front end *O* of the lever is supported in an eye, *c c* (shown clearly in fig. 309), which is formed in the lower end of the center-pin *S*. This pin passes through the hollow king-bolt *K K*, and is supported by a pair of nuts screwed in the upper end, and which bear on the top of the king-bolt. The king-bolt can slide vertically in the casting *B B*. *A* is the lever *O P Q*, and this would exert a downward pressure on the front end *O*, which would be transferred by the center-pin *S* to the top of the king-bolt *K K*, and by it to the bolster *H*, which is suspended by links *L L* to truck frame. Any undue weight resting on one or both of the driving-wheels would thus be transmitted to the truck, and a reverse action will occur if the truck wheels *W W* bear any undue weight.

QUESTION 489. *How does such a truck adjust itself to the curvature of the track?*

Answer. The two center-pins, *S* and *s*, are both attached to the locomotive on its center line, represented by *U V*, fig. 308,

and they cannot move away from that line. If the truck wheels *W W* encounter a curve they must move sideways in relation to the engine. This they are enabled to do by reason of the bolster *H* being suspended from the truck frames by the links *L L L L*. The lower ends of these links can swing in relation to the upper ones, as indicated by the arcs *a b* and *b a*, in fig. 301, or the upper ends can move in relation to the lower ones, as shown in fig. *c*. When the front end of the locomotive enters a curve, the wheels and the truck frame move laterally and carry the upper ends of the links toward *a a* or *b b*, according to the direction of inclination of the curve, and the bolster *H*, center-pin *S*, and king-bolt *K K*, all retain their central position in relation to the engine. When the truck wheels move laterally their axle, instead of being parallel to the driving-axle, becomes inclined to it, as shown by the dotted center lines *g t* and *c d*, fig. 276, and on a curve the position of the center line of the truck-axle approximates to that of a radius of a curve on which the engine is moving or standing.

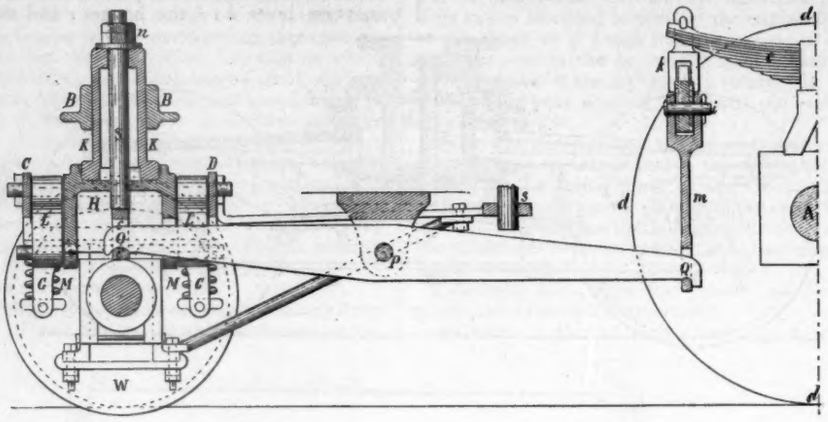


Fig. 307.

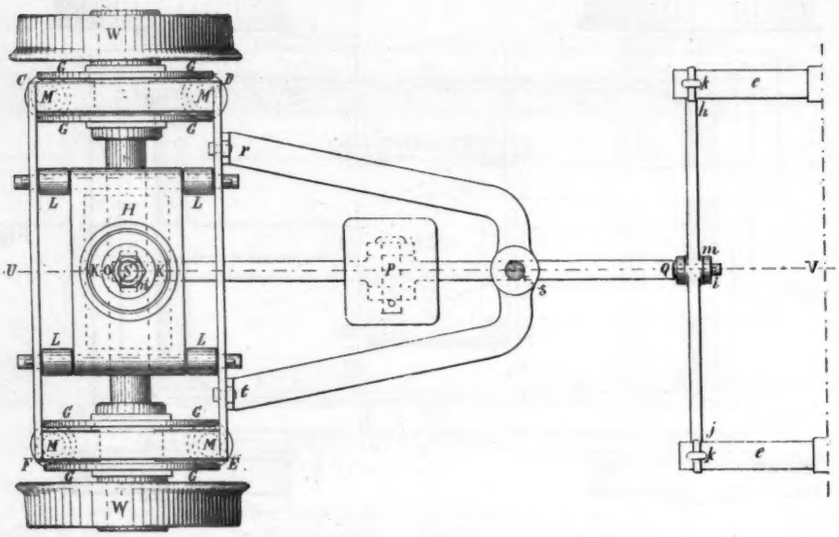


Fig. 308.

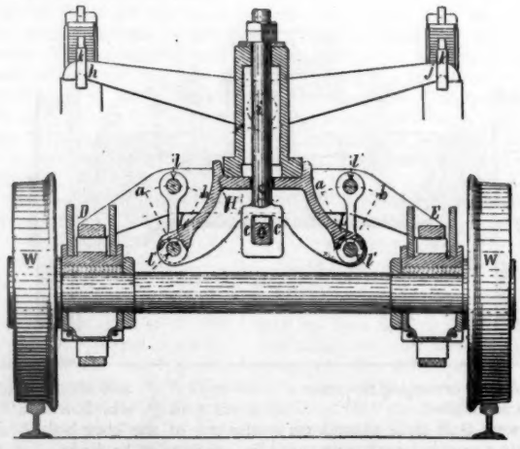


Fig. 309.

QUESTION 490. *How are the springs of a pony truck arranged?*

Answer. In the truck shown by figs. 307, 308 and 309 spiral springs *M M* are used. These are placed underneath the frames, as shown, and ∩-shaped yokes *G G*, *G G* rest on top of the axle-boxes and are coupled to a cup-shaped casting under the springs, and on which they rest. The form of these yokes is shown partly by dotted lines in fig. 307.

QUESTION 491. *What advantage does the use of a pony truck give over one with four wheels?*

Answer. It permits of the front driving-wheels being placed closer to the cylinders than is possible when one pair of the truck wheels is behind the cylinders, as it usually is when a four-wheeled truck is used. If the driving-wheels are located nearer to the cylinders they will bear a larger proportion

of the weight of the engine than they do if they are further back.

CHAPTER XVII.

MISCELLANEOUS.

QUESTION 492. *What is a sand-box of a locomotive, and how is it constructed?*

Answer. A sand-box, 39, Plates III and IV, is usually a cylindrical receptacle which is made of sheet iron with a cast-iron base, and a top of a more or less ornamental design. It

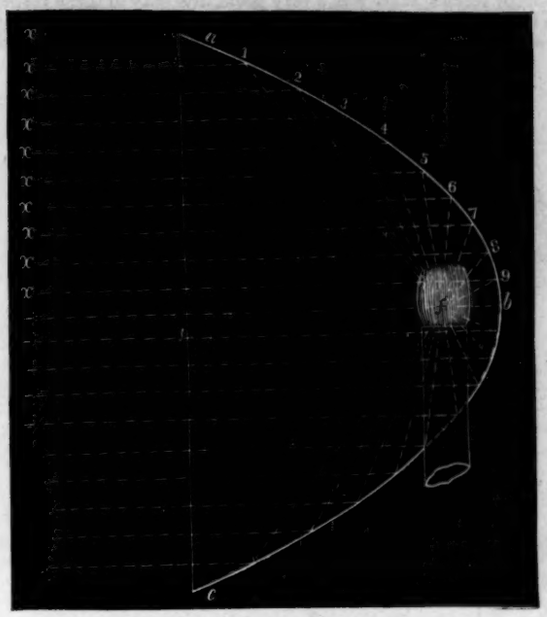


Fig. 310.

is generally placed on top of the boiler and is intended to carry a supply of dry sand, which is scattered on the rails in front of the driving-wheels when the latter are liable to slip. This is done by pipes, 40, Plate III, one on each side of the engine. They lead from the sand-box to within a few inches of the rail. At the upper end and inside the sand-box they each have a valve which is operated by a lever connected to the cab by a rod so that the locomotive runner can open or close the valve at pleasure. The sand-box has an opening on top through which the sand is supplied to the box. This opening has a loose cover to exclude rain and dirt from the sand.

QUESTION 493. *What is the bell, 41, Plates III and IV, for?*

Answer. It is used for giving signals of the starting or approach of the engine. It also is located on top of the boiler and is usually hung on a cast-iron frame and rung with a rope, shown in Plate III, connecting it with the cab. Locomotive bells usually weigh from 50 to 100 lbs.

QUESTION 494. *What is the signal-gong?*

Answer. It is a gong-bell with a hammer or clapper attached to it, and fastened, usually, to the under side of the roof of the cab. The train bell-cord is connected to the hammer, by which the bell can be rung from any part of the train to signal to the engineer to start or stop the engine.

QUESTION 495. *What is a locomotive head-light?*

Answer. It is a large lamp, 35, Plates III and IV, placed in front of the locomotive to signal its approach at night and also to illuminate the track for the locomotive runner.

QUESTION 496. *How is a head-light constructed?*

Answer. The lamp has what is called an Argand burner; that is, a burner with a hollow cylindrical wick through the center of which a current of air circulates which thus supplies the flame with a larger quantity of air than is possible if the air can come in contact with the burner only on the outside. The result is that the combustion of an Argand burner is much more brilliant than that of ordinary burners. In order to throw all the light on the track the burner is placed inside of a concave reflector, *a b c*, fig. 310, which is of a *parabolic* form. One of the peculiarities of this form of reflector is that if a light is placed in its focus *f* the rays will be reflected from its surface in parallel lines. Thus, let *a b c*, fig. 310, represent a section of such a reflector. Now, if a light be placed in the focus *f* the rays will strike against the reflector in the direction of the dotted lines *f* 1, *f* 2 . . . *f* 9, etc., and be reflected in straight horizontal lines 1 *x*, 2 *x*, 3 *x*, etc., and thus be thrown directly in front of the engine. The reflectors are usually made of copper and plated with silver.

The lamps and reflectors for head-lights are enclosed in a rectangular case which is placed on top of the smoke-box, or is supported on two brackets bolted to the front of the smoke-box. On these brackets a wooden shelf is fastened on which the head-light rests.

QUESTION 497. *What are the running-boards and hand-rails?*

Answer. The *running-boards* are narrow platforms, made of wood or iron, 56, 56, Plate III, placed on each side of the boiler to enable the locomotive runner or fireman to go from the cab to the front end of the engine when it is running. The hand-rails, 57, 57, are brass or iron pipes attached to the top of the boiler and extending from the cab to the smoke-box, and are placed there, as their name indicates, for persons on the running-board to take hold of.

QUESTION 498. *What provision is made for removing from the track obstacles such as cattle, fallen rocks, etc., which may be in front of locomotives?*

Answer. What is called a *cow-catcher* or *pilot*, 38, Plates III and IV, is attached to the front of the locomotive. This is usually made of wood, and consists of a triangular frame at the bottom, which is supported so that it is a few inches above the tops of the rails. Straight pieces of wood of about $2\frac{1}{2} \times 4$ in. section are fastened to this frame and also to a horizontal piece which is bolted to the bumper-timber. These pieces when arranged in this way, and only a few inches apart, give to the cow-catcher a peculiar curved form—somewhat resembling that of the mould-board of a plow—which is very well adapted for throwing any obstacles from the track. Sometimes these pieces are placed horizontally instead of being inclined up and down. Cow-catchers are also in some cases made of round iron bars or angle iron. They are always bolted securely to the bumper-timber and strengthened by strong iron braces attached to the bottom frame at the front and back. These braces are usually fastened at the other end to the bumper-timber, but are sometimes attached to the bed-plates of the cylinder.

There is also usually a strong *pushing-bar*, 79, attached with a bolt and hinged joint to the bumper-timber. This is shown in Plates IV and V in the position it occupies when not in use. It is used in pushing cars, as very often there is not room for the pilot under the end of the car. In using it, it is raised up, and the front end is then coupled to the draw-head of the car.

Iron plates and scrapers are often attached to the pilots in winter to remove snow from the track.

QUESTION 499. *What is the foot-board or foot-plate of a locomotive?*

Answer. It is a wrought or cast-iron plate, 95, Plate IV, which extends across and rests upon the two frames at the back part of the locomotive and behind the boiler, and on which the locomotive runner and fireman stand. It also unites the two frames very securely, and furnishes an attachment for the draw-bar.

QUESTION 500. *What other purpose is the foot-board sometimes made to serve?*

Answer. It is sometimes made much heavier than is necessary for strength in order to increase the weight, and thus the

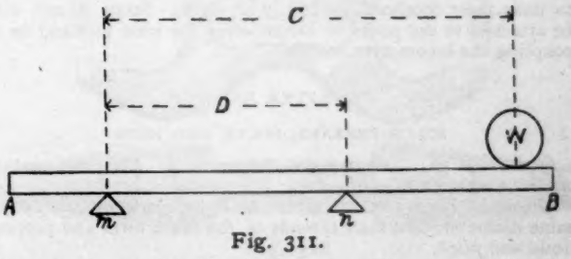


Fig. 311.

adhesion, on the driving-wheels. It is a fact often not suspected that any weight placed on the back end of an ordinary locomotive will increase the load on the driving-wheels by an amount considerably greater than that of the weight itself. The reason of this is that the locomotive rests on the center of the truck and the centers of the equalizers, and therefore the weight, if applied to the back end of the engine, gains considerable leverage. This will be clear if we take a beam, *A B*, and rest it on two supports, *m* and *n*, fig. 311. If, now, we put a weight *W* on the end, overhanging the point of support, the weight which will rest on *n* will be equal to that of *W* multiplied by its distance *C* from *m* and divided by the distance *D* between *m* and *n*. Thus if a foot-board weighs 1,000 pounds, and its center of gravity is $5\frac{1}{2}$ ft. behind the center of the equalizer,

and the latter 14 ft. from the center of the truck, then the weight thrown on the driving-wheels will be equal to

$$\frac{1{,}000 \times 19\frac{1}{2}}{14} = 1{,}393 \text{ pounds.}$$

The same thing is, of course, true of any other weight placed on the back end of the engine.

QUESTION 501. *What are the "wheel-guards" of a locomotive?*

Answer. They are sheet iron covers, 61, 61, Plate III, over the upper half of the periphery or tread of the wheels, and are placed there to protect the engine from the dirt and mud which adhere to the wheels, and are then thrown off on the machinery by the centrifugal force.

Fig. 312.

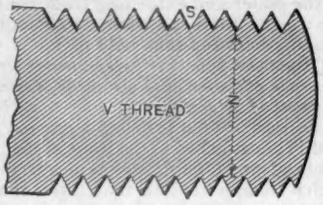


Fig. 313.

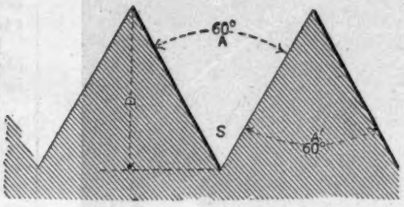


Fig. 314.

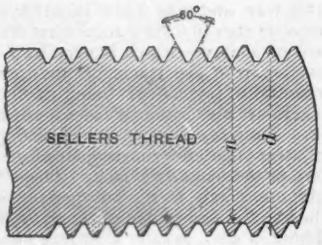
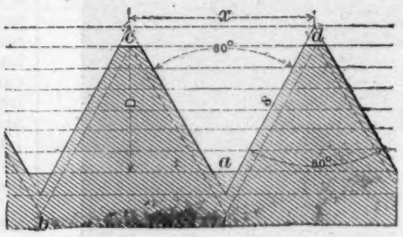


Fig. 315.



QUESTION 502. *What are "check" or "safety chains?"*

Answer. There are two kinds of such chains, the one, 78, Plates III and IV, attached to the trucks and frames of the locomotive and the tender. The object of these chains is to prevent the trucks from turning around and getting crosswise of the track if the trucks should leave the rails. The other kind of safety chains, 50, Plates III and IV, connect the engine to the tender, so that, in case the draw-bar or coupling-pins should break, the two will not separate. Great care should be exercised to attach the truck chains so as to be strong enough to resist the strains to which they will be subjected in case the trucks run off the track. The grossest carelessness and ignorance are often shown in the construction of these parts.

QUESTION 503. *Where should steps be placed on locomotives?*

Answer. Steps should be attached to the back end of the locomotive, as shown by 101, Plates III, IV and V, to enable the men to get on and off the foot-board. Such steps are usually made too small, so that those who use them are liable to miss their foothold, especially at night. Steps should also be attached to the pilots of locomotives for men to stand on in coupling the locomotive to cars.

CHAPTER XVIII.

SCREW-THREADS, BOLTS, AND NUTS.

QUESTION 504. *How must the screws of bolts and nuts be made, in order to fit each other?*

Answer. Each size of screw must be made of exactly the same diameter, and their threads of the same form and proportions and *pitch*.

QUESTION 505. *What is meant by the "pitch" of a thread?*

Answer. It is the distance the thread progresses lengthwise of the screw in one revolution. Thus if a single-threaded screw has $\frac{1}{8}$ of an inch pitch, it means that the threads are $\frac{1}{8}$ of an inch apart measured from the center of one thread to the center of that next to it, and therefore there are eight threads to each inch in length of the screw.

QUESTION 506. *What is meant by a "single-threaded" screw?*

Answer. It means a screw with but one thread instead of two or more. Thus if we take a string and wind it around a pencil, it will represent a single-threaded screw, and if we take two or three strings and wind them parallel to each other, they will represent double or treble-threaded screws. The latter kinds are seldom or never used on locomotives, so that in the following discussion only single-threaded screws will be referred to.

QUESTION 507. *What is the usual form of the threads of screws?*

Answer. Until a few years ago the most common form was what is called the V-thread, represented in fig. 312 (and on an exaggerated scale in fig. 313), which was made sharp at both the top and bottom. It is evident that if such a thread for one screw is made very pointed, and that for another is blunt, that the nut for the one will not fit the other accurately, and also that if a nut has eight threads to the inch, it will not fit on a bolt with nine. Owing to the fact that, for a long time, no common standard had been agreed upon for the form, proportions or pitch of screws, there was a very great diversity in these respects in the screws which have been used in the construction of locomotives and other machinery. In 1864 the inconvenience and confusion from this cause became so great that it attracted the attention of the Franklin Institute of Philadelphia, and a committee was appointed by that association to investigate and report on the subject. That committee recommended the adoption of the Sellers system of screw-threads and bolts, which was devised by Mr. William Sellers, of Philadelphia. This same system was subsequently adopted as the standard by both the Army and Navy Departments of the United States, and then by the Master Mechanics' and Master Car Builders' associations, so that it may now be regarded, and in fact is called, the United States standard, but the design is due to Mr. Sellers.

QUESTION 508. *In establishing a standard system of screws and threads, what is the first thing which must be determined?*

Answer. The number of threads to the inch, or the pitch of the threads for screws of different diameters.

QUESTION 509. *What is the standard for the number of threads to the inch for the different sized screws of the Sellers system?*

Answer. The number of threads with their other proportion is given in the table at the end of this chapter.

QUESTION 510. *What is the form of the thread of this standard?*

Answer. The form is shown in fig. 314, and on an exaggerated scale by fig. 315. It is similar to the V-thread, excepting that it is flattened at the top and bottom.

QUESTION 511. *What advantages has the Sellers form of screw-threads over the old V-form?*

Answer. The flattened point or edge makes the thread less liable to injury by being battered, and the diameter—and consequently the strength—of a screw with a Sellers thread at *n*, fig. 315, at the root of the thread, is considerably greater than a thread of the V-form.

QUESTION 512. *What other reasons are there for the adoption of this form of thread?*

Answer. It has already been pointed out that if a screw is made with a "blunt" thread it will not fit a nut with very acute or "sharp" thread; or, if the thread of the bolt is acute and that in the nut obtuse, they will fit imperfectly. It is therefore necessary in a standard system to fix upon the angle which the sides of the thread shall bear to each other. This in the United States standard system was determined by Mr. Sellers at 60 degrees, because that angle is easily laid off without special instruments* and is, perhaps, as good as or better than any other form for the threads.

* This can be done by drawing a circle of any diameter, and subdividing the circumference into six equal parts with the radius. Lines drawn from the points of division to the centre will have an inclination of 60 degrees to each other.

It is obvious that if a tool is ground with its sides at an angle of 60 degrees to each other, if the point is made sharp, after a very little use it will be worn more or less so that the bottom of the thread will not be cut perfectly sharp, and therefore it will be difficult to make bolts and nuts with threads of this form fit each other accurately. It is also plain that the sharp edge of a thread gives very little strength to the screw, and yet diminishes that of the bolt very materially. It will also be impossible to measure the diameter of the screw at the bottom of the thread if it is made sharp, as its depth will vary as the point of the tool wears, and it is almost impossible to measure the diameter of such a screw accurately with ordinary calipers. To

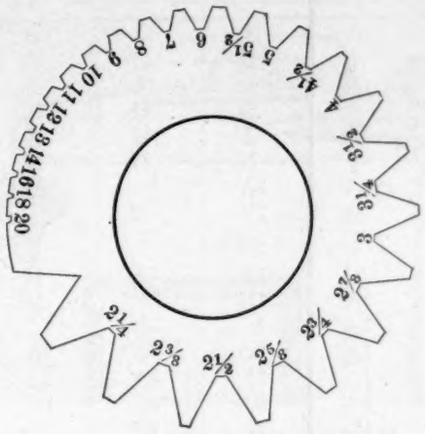


Fig. 316.

obviate these evils the standard threads are made flat on the top, and it is evident—as has been pointed out—that a similar shape at the bottom will give increased strength to the bolt as well as conform to and fit the thread in the nut. To give this form requires only that the point of the cutting tool shall be taken off, and it is evident that then this form of thread can be cut in a lathe with the same tool and in the same manner as the sharp thread. The width of the flat top and bottom should, of course, bear a definite proportion to the size or pitch of the thread.

QUESTION 513. *What are the proportions of the standard threads?*

Answer. The rule given by Mr. Sellers for proportioning the thread is as follows: "DIVIDE THE PITCH, OR, WHAT IS THE SAME THING, THE SIDE OF THE THREAD, INTO EIGHT EQUAL PARTS; TAKE OFF ONE PART FROM THE TOP AND FILL IN ONE PART IN THE BOTTOM OF THE THREAD: THEN THE FLAT TOP AND BOTTOM WILL EQUAL ONE-EIGHTH OF THE PITCH, THE WEARING SURFACE WILL BE THREE-QUARTERS OF THE PITCH, AND THE DIAMETER OF SCREW AT BOTTOM OF THE THREAD WILL BE GIVEN IF WE DIVIDE 1.299 BY THE NUMBER OF THREADS PER INCH AND DEDUCT THE QUOTIENT FROM THE OUTSIDE DIAMETER OF THE SCREW.

To show the form and proportions of the thread fig. 315 has been drawn eight times the size of a thread for a bolt one inch in diameter, so as to represent the different parts clearly; x represents the pitch and D the depth of the thread; d, fig. 314, represents the outside diameter of the screw, and n the diameter at the bottom or root of the thread. The width of the flat part of the thread at the top and the bottom of the threads is shown at c, d and a, fig. 312, and s indicates the length of the side or wearing surface of the thread.

The dotted lines $b\,c$, $c\,e$, $e\,d$ show the form of a V-thread, and the distance from a to e shows—on an exaggerated scale—how much more metal must be cut away at the root of the thread if it is made of the V-shape than if it is of the standard Sellers form.

For practical use in the shop a gauge like that shown in fig. 316 will be found convenient for grinding the tools to the proper form for making the standard screws. With this gauge the screw-cutting tool can first be ground to the proper angle by fitting it to the deepest notch, and the requisite quantity should then be taken off the point by fitting it to the notch representing the form of thread for the sized bolt or number of threads to the inch which it is intended to cut.

Wherever this standard for threads is used, if any pretense at all is made to accuracy of workmanship, careful attention should be given to the form and proportion of the threads as well as to the number to the inch.

QUESTION 514. *What other precaution must be taken to secure interchangeability of screw bolts and nuts?*

Answer. Great care must be taken that the diameters of the screws are accurately maintained to the standard sizes. The diameters of the standard sizes of screws are given in the table at the end of the chapter. It has been a common practice to make screws somewhat larger than these sizes because iron is often rolled larger in diameter than its nominal size, and then the superfluous metal must be cut away to reduce the screw to the standard size. It should be distinctly known that there are no standard screws for bolts and nuts which are a small fraction of an inch larger or smaller than the diameters given in the tables, and that a screw slightly larger or smaller in diameter than the sizes given does not conform to the standard.

QUESTION 515. *What has been done to secure uniformity in the diameters of screws?*

Answer. The Master Mechanics' and the Master Car Builders' associations have adopted limits for the diameter of round bar iron. It has been specified by these associations that such iron shall not vary from its nominal size more than the amount given in the following table:

LIMITS OF SIZE OF ROUND ROLLED IRON.

Nominal Diameter of Iron. Inches.	Maximum or + Size. Inches.	Minimum or — Size. Inches.	Total Variation. Inches.
¼	.2550	.2450	.010
5/16	.3180	.3070	.011
⅜	.3810	.3690	.012
7/16	.4440	.4310	.013
½	.5070	.4930	.014
9/16	.5700	.5550	.015
⅝	.6330	.6170	.016
¾	.7585	.7415	.017
⅞	.8840	.8660	.018
1	1.0093	.9905	.019
1⅛	1.1350	1.1150	.020
1¼	1.2605	1.2395	.021

Caliper gauges, like that shown in fig. 317, are made by the Pratt-Whitney Company, of Hartford, Conn., for measuring bar iron. The two ends of the gauges are made of the maximum and minimum dimensions given in the table, and the associations already referred to have recommended "that round iron of the nominal standard sizes be made of such diameter that each size *will* enter the large or + end of the gauge intended for it, *in any way*, and will *not* enter the small or — end *in any way*."*

In buying taps and dies the purchaser should see that they conform in every respect to the standard, and in making specifications for new work similar care should be exercised to secure the true standard, form, and proportion of screws. In

Fig. 317.

Fig. 318.

many shops the workmen who have the care of those tools are entirely ignorant of the peculiarities of the Sellers system, and have only the vague idea that so long as they get the proper number of threads to the inch they are doing all that is necessary to secure uniformity. Unless, therefore, some care is exercised to insure accuracy of workmanship in this department, the adoption of a "standard" for screws will not insure the advantages which would result from uniformity of screws and threads.

QUESTION 516. *What is the usual shape of nuts?*

Answer. The most common shape is square or hexagonal, as shown in figs. 319–322, but they are sometimes made cylin-

* Fig. 318 is a reference gauge which is used for testing the caliper gauges shown in fig. 317.

TABLE OF DIMENSIONS OF SELLERS' STANDARD SCREW-THREADS, NUTS AND BOLTS.

Screw-Threads.				Nuts.				Bolt Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
1/4	20	.185	.0062	1/2	7/16	1/4	3/16	1/2	7/16	1/4	3/16
5/16	18	.240	.0074	19/32	17/32	5/16	1/4	19/32	17/32	19/64	1/4
3/8	16	.294	.0078	11/16	5/8	3/8	5/16	11/16	5/8	11/32	5/16
7/16	14	.344	.0089	25/32	23/32	7/16	3/8	25/32	23/32	25/64	3/8
1/2	13	.400	.0096	7/8	13/16	1/2	7/16	7/8	13/16	7/16	7/16
9/16	12	.454	.0104	31/32	29/32	9/16	1/2	31/32	29/32	31/64	1/2
5/8	11	.507	.0113	1 1/16	1	5/8	9/16	1 1/16	1	17/32	9/16
3/4	10	.620	.0125	1 1/4	1 3/16	3/4	11/16	1 1/4	1 3/16	5/8	11/16
7/8	9	.731	.0138	1 7/16	1 3/8	7/8	13/16	1 7/16	1 3/8	23/32	13/16
1	8	.837	.0156	1 5/8	1 9/16	1	15/16	1 5/8	1 9/16	13/16	15/16
1 1/8	7	.940	.0178	1 13/16	1 3/4	1 1/8	1 1/16	1 13/16	1 3/4	29/32	1 1/16
1 1/4	7	1.065	.0178	2	1 15/16	1 1/4	1 3/16	2	1 15/16	1	1 3/16
1 3/8	6	1.160	.0208	2 3/16	2 1/8	1 3/8	1 5/16	2 3/16	2 1/8	1 3/32	1 5/16
1 1/2	6	1.284	.0208	2 3/8	2 5/16	1 1/2	1 7/16	2 3/8	2 5/16	1 3/16	1 7/16
1 5/8	5 1/2	1.389	.0227	2 9/16	2 1/2	1 5/8	1 9/16	2 9/16	2 1/2	1 9/32	1 9/16
1 3/4	5	1.491	.0250	2 3/4	2 11/16	1 3/4	1 11/16	2 3/4	2 11/16	1 3/8	1 11/16
1 7/8	5	1.616	.0250	2 15/16	2 7/8	1 7/8	1 13/16	2 15/16	2 7/8	1 15/32	1 13/16
2	4 1/2	1.712	.0277	3 1/8	3 1/16	2	1 15/16	3 1/8	3 1/16	1 9/16	1 15/16

drical, as shown in figs. 323 and 324, with grooves cut on the outside to hold a wrench.

Question 517. *Why is it often essential to adopt some means to prevent nuts from turning or unscrewing?*

Answer. When bolts and nuts are exposed to vibration, it is found that a slackening is very liable to occur, so that the excessive vibration on locomotives requires that many of the nuts should be locked in some way.

Question 518. *How are nuts prevented from turning?*

Answer. The simplest plan, and the one which is most frequently employed, is that shown in figs. 325 and 326, which is simply a second nut screwed on over the first and tightened down upon it. Lock nuts are usually made thinner than the main nut, and when that is the case, it is argued that the thinnest nut should be screwed on the bolt first, because if the second nut is screwed down hard on the first one, the strain on the bolt is borne by the one last screwed on.

Fig. 319. Fig. 321. Fig. 323. Fig. 325.

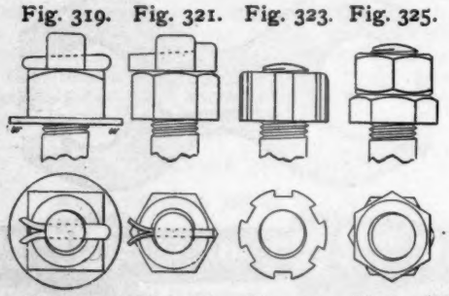


Fig. 320. Fig. 322. Fig. 324. Fig. 326.

When lock nuts are used, if the total thickness of the two nuts is equal to about one half more than the ordinary proportion for the thickness of nuts, it will be found that sufficient has been done to insure a perfect locking.

When the object is merely to prevent nuts from unscrewing and being lost, what are called *split keys* or *cotters* are used. These are sometimes round, tapered pins, shown in figs. 319 and 320, which are divided or split so that the two parts can be bent into the form shown in fig. 320. In other cases they are made of flat pieces of metal, as shown in figs. 321 and 322, which are bent as shown in fig. 322.

Question 519. *What are the shapes of bolt-heads?*

Answer. They are made in a variety of forms according to their use, but usually they are either square or hexagonal, the same as nuts.

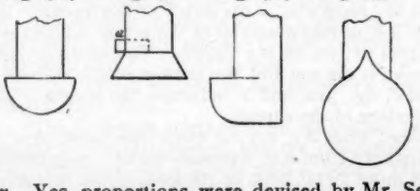
Question 520. *In what other forms are bolt-heads made?*

Answer. Fig. 327 represents a bolt with a hemispherical head, and fig. 328 one with a countersunk head. The latter form is used when a projecting head would be in the way of something else. To prevent the bolt from turning when a hemispherical or countersunk head is used, a hole is sometimes drilled into the side of the bolt and a pin *a*, fig. 328, is fitted into it. This pin rests in a corresponding cavity cut in the side of the hole in which the bolt fits.

Fig. 329 represents a hook-headed bolt, which is sometimes used to fasten tires on wheel centers. Fig. 330 is the form of bolt-head used to move the wedges which form the wearing surface for driving-axle boxes.

Question 521. *Are there any standard sizes for bolt-heads and nuts?*

Fig. 327. Fig. 328. Fig. 329. Fig. 330.



Answer. Yes, proportions were devised by Mr. Sellers and were adopted by the associations already referred to. These are given in the table at the end of this chapter.

Question 522. *What is a washer?*

Answer. A washer, shown at *w w*, fig. 319 and in fig. 320, is a ring of metal or other material, which is put under a bolt-head or nut to give it a fair bearing. Washers are also put between bolt-heads or nuts when they bear on wood or other yielding material to increase the area of their bearing.

Question 523. *What is a stud?*

Answer. A stud is a bolt with a nut in place of a head. Studs are screwed into their place and are provided with nuts instead of heads, so that the stud need not be unscrewed to loosen or remove the parts which it secures or fastens. Studs are generally used to make attachments to cast-iron, because a thread cut in cast-iron is liable to be injured by screwing and unscrewing a bolt into and from it.

(to be continued.)

Manufactures.

A New Combined Door Spring and Check.

THE accompanying illustrations represent a combined door spring and check, which presents some new and excellent features. Fig. 1 is a perspective view and fig. 2 a plan; the operation of the spring will be readily understood from the engravings. The frame *A* is fixed to the door casing, and the bracket *D* to the door, and the oscillating lever *C*, which is pivoted to

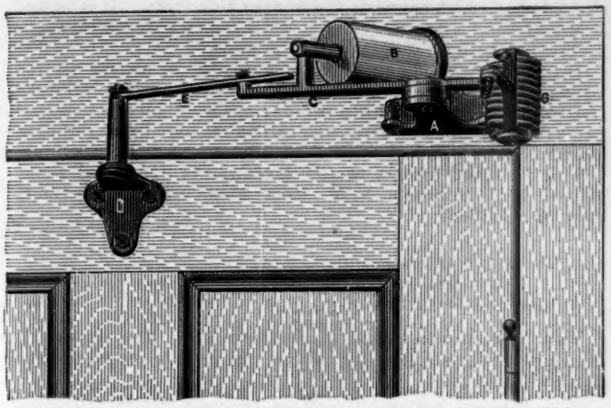


Fig. 1.

the other end of the frame *A*, is connected to the bracket *D* by the link *E*. The spring *G* carries two toggle-arms, one of which is pivoted to the frame, and the other attached to the short arm of the lever *C* by a flat link chain. The air cylinder *B* is pivoted to the frame *A* at its base, while its piston-rod is pivoted to the lever *C*. The piston of this air cylinder is of the ordinary cup pattern with a valve in the center. This valve consists of the tapered end of the piston-rod fitting into a seat in the piston, and is so arranged that when the piston is drawn backward the valve

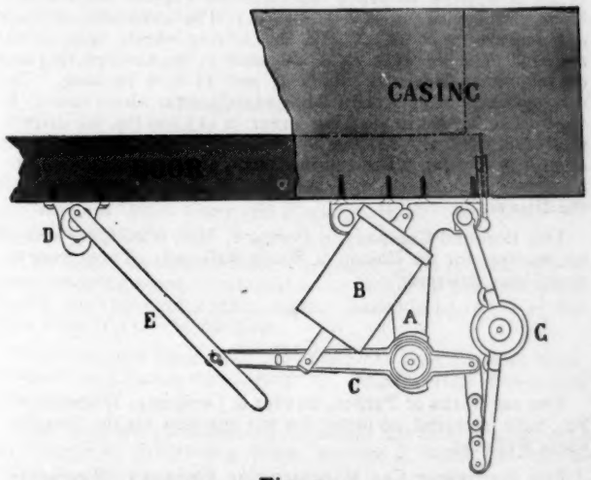


Fig. 2.

is opened and allows the air to pass through; when the motion is reversed the valve is closed and the air compressed in front of the piston. To allow a slow closing motion, an arrangement is made for the escape of a small volume of air through the piston by means of a very small slot cut in the valve seat.

When the door is opened the lever *C* draws the chain toward its pivot until engaged by the eccentric segmental drum, around which it winds so that when the door is wide open the spring is at its maximum tension, while with the chain around the drum it imparts its minimum power to the door. Thus the first motion of closing is slow, but is gradually increased in speed as it proceeds until checked by the air cushion in the cylinder. The greatest power is exerted upon the door by the spring when it is at its least tension and the door is nearly shut; this is for the purpose of overcoming the resistance of the latch, wind, etc.

These springs and checks are so made that they can be used for either right or left-hand doors by a very simple change, which can be effected in a minute, and consists in merely reversing the lever and bracket. It is readily adjusted by means of the hole and small pins provided in the lever and connecting rod *E*.

Several sizes of these springs and checks are made by the manufacturers, the Russell & Erwin Manufacturing Company, of New Britain, Conn., and New York. One of these is especially intended for car doors, and is now extensively used on the Boston & Albany, and on several other New England roads.

The spring fulfills very well all the requirements of a good door spring. It is simple in all its parts, can be quickly and easily put up, and is not liable to get out of order, while it prevents entirely the too quick closing and banging of the door, which is an unpleasant feature of almost all springs now in use.

Blast Furnaces of the United States.

THE *American Manufacturer*, in its usual monthly tables, gives the condition of the blast furnaces on October 1, and sums up as below.

"The totals are as follows:

Fuel.	In Blast. No.	In Blast. Weekly capacity.	Out of Blast. No.	Out of Blast. Weekly capacity.
Charcoal	73	12,983	96	11,696
Anthracite	99	29,586	97	24,548
Bituminous	138	87,141	89	42,845
Total	310	129,710	282	79,089

"Our table shows that the number of furnaces in blast on October 1 was 310, compared with 298 in blast on September 1—an increase of 12. The increase by classes is divided as follows: Charcoal, 5; anthracite, 1; bituminous, 6. The weekly capacity of the furnaces in blast was 129,710 tons, compared with 126,082 tons on Sepember 1, the increase being distributed as follows: Charcoal, 360 tons; anthracite, 640 tons; bituminous, 2,628 tons.

"The appended table shows the number of furnaces in blast October 1, 1888, and on October 1, 1887, with their weekly capacity:

Fuel.	Oct. 1, 1888. No.	Oct. 1, 1888. Weekly capacity.	Oct. 1, 1887. No.	Oct. 1, 1887. Weekly capacity.
Charcoal	73	12,983	73	15,171
Anthracite	99	29,586	122	36,044
Bituminous	138	87,141	151	93,423
Total	310	129,710	346	144,638

"This table shows that the number of furnaces in blast October 1 last was 36 less than at the same date in 1887, the decrease being distributed as follows: Charcoal, no change; anthracite, 23; bituminous, 13. The weekly capacity of the furnaces blowing was 129,714 tons: at the corresponding date last year, 144,638—decrease, 14,928 tons."

Twin-Screw Steamers.

TWIN screws, driven by triple-expansion engines, have in so many cases proved more effective and economical than the side-wheelers and propellers built a few years ago, that the question of converting old side-wheel steamers into twin screws is likely to arise. The experience of an English railroad company in this direction is therefore interesting. The London & Northwestern Railway some months since placed their paddle-wheel steamer *Duchess of Sutherland* (built in 1869) in the hands of Messrs. Laird Brothers for conversion into a twin-screw steamer, with the expectation that her efficiency for their cross-channel cattle trade would be improved, and that considerable gain in economy would result from the introduction of more modern machinery. The work has been completed, and on a recent trial trip the vessel ran 14½ knots, the engines developing 1,400 H. P. The old machinery, side-wheels, and boxes were removed, but the forward and after sponsons or guards and their houses on each side are retained and connected, the houses forming quarters for the ship's officers, store-rooms, etc. The old side-wheel space is decked over and formed into a large additional space for cattle. The necessary alterations have been made about the stern of the vessel, and stern tubes and brackets fitted, and the arrangement of engine keelsons, bulkheads, coal-bunkers, etc., has been modified to suit the new machinery. This consists of two sets of triple-expansion engines having cylinders 16½ in., 26 in., and 41 in. diameter, with a stroke of 30 in., and working at 150 lbs. pressure, steam being provided by

two double-ended cylindrical Scotch steel boilers. The carrying power of the vessel has been increased by about 190 tons, large additional deck space for cattle gained, while the net register tonnage has been reduced by 247 tons. The speed has been considerably increased, and the consumption of fuel reduced.—*Marine Journal.*

A New Railroad Ditcher.

THE accompanying illustrations show machinery which is designed to take a place between the wheel scraper and steam shovel, and to fill a vacancy as a ditcher in railroad maintenance of way, doing away with the expense and weight of the steam shovel, as well as the expense incurred in hauling with the wheel scraper at long distances.

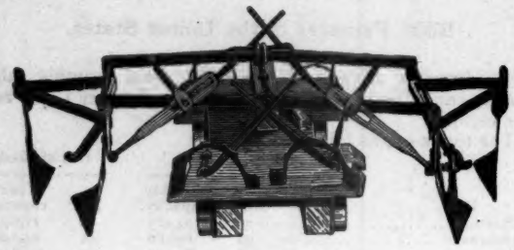


Fig. 1.

In these illustrations fig. 1 shows the plows; fig. 2 is a front view of the scrapers, and fig. 3 a perspective view of the same.

The appliances consist of plows and scrapers attached to the sides of a car so as to excavate to a considerable depth below or above the rail. The plows are necessarily of strong construction, enough to loosen any earth which can be removed without blasting. The side-arms, which are pivoted on the center beam of the car and to the plow-beams, allow the plowing to any height from 2 ft. below the rail to the top of the car, and keep the plows parallel to the track. The brace-rod is hooked into an eye on the side of the forward plow and slotted over a stud on the fore side-arms, where it is fastened with a nut so as to maintain the desired angle between plows and car. The scraper boxes on the excavators being connected to the car by arms of similar length and range, cause the scrapers to follow exactly in the line of loosened material, thus allowing a much lighter construction of scrapers in all their parts than would be necessary if they had to be drawn through unplowed ground.

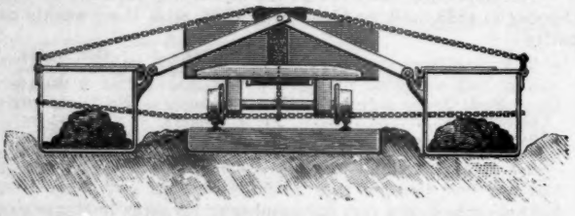


Fig. 2.

Fig. 3.

The weight of this excavator does not greatly exceed that of an ordinary dump car. The center of gravity is lower than that of any car of equal capacity. The scrapers for a 3-ft. gauge car are 3 ft. wide, 4 ft. long and 2 ft. deep. For a standard-gauge ditcher wider at top than bottom, say 4 ft. wide at top, 3 ft. at bottom, 5 ft. long, and 2½ ft. deep.

In operating, the plow is drawn through the cut at such depth as the nature of the material will permit, after which the scrapers are thrown outward from the car, and the loading chains hooked to the bails; the scrapers are then drawn forward until filled. Then the car is secured to the track by the means of dogs, and power is applied to the hoisting chains which turn the scrapers over and on the car. The car is then ready to be moved to the dump. The lid or cover of the scraper when loading becomes the bottom when turned on to the car, and is hinged and latched so as to be easily and effectively dumped. In excavating new cuts the track is thrown from side to side as each cut is taken out until the cut is finished. The strain of drawing plows and scrapers through the earth is directly from the power, so that there is no strain on the car or tendency to throw it from the track. An end-gate for the excavator is provided, which revolves on the side-bar which connects the scraper side-arms. It is turned down by hand after the scraper is loaded, which prevents the spilling of earth on the way to the dump.

Eight men will be needed for operating these excavators and plows. In ordinary materials, with steam power, they will take out 500 cubic yards of earth per day. These cars have no expensive or complicated parts, and can be repaired by an ordinary blacksmith.

This plow and scraper are the invention of Mr. Frank Nearing, C. E., Tarrytown, N. Y., from whom further particulars may be obtained.

Locomotives.

THE New Haven shops of the New York, New Haven & Hartford Railroad recently turned out a new mogul freight engine for the road.

THE Baldwin Locomotive Works in Philadelphia have received from the Northern Pacific Company an order for 82 locomotives, probably the largest order of the kind ever placed at one time.

THE Valley Railroad Company is now testing practically the use of oil as fuel for locomotives on an engine which is in use shifting in the yard at Cleveland, O. Other engines are to be fitted up shortly.

THE Brooks Locomotive Works, Dunkirk, N. Y., have an order for 18 mogul engines for the Lake Shore & Michigan Southern road.

THE Brooks Locomotive Works at Dunkirk, N. Y., have recently completed 10 heavy consolidation engines for the New York, Pennsylvania & Ohio road. The cylinders of these engines are 20 × 24 in., and the driving-wheels have 44 in. centers. The boiler is 60 in. diameter at the smallest ring and contains 240 flues 2 in. diameter and 11 ft. 6 in. long. The driving-wheel base is 15 ft. 2 in., and the total wheel base 23 ft. 7 in. The weight in working order is 113,500 lbs. on drivers, total 128,000 lbs. The tender holds 3,600 gallons and weighs empty 33,500 lbs. The engines have straight stacks and extension smoke-boxes, and the American steam brake on all the drivers.

THE Portland Company in Portland, Me., is building several locomotives for the Boston & Maine Railroad. Three have already been delivered.

Cars.

THE car works of Pardee, Snyder & Company, Watsontown, Pa., have received an order for 200 box cars for the Pennsylvania Railroad.

THE Harrisburg Car Manufacturing Company, Harrisburg, Pa., is building 100 tank cars for the Standard Oil Company.

THE Lebanon Manufacturing Company, Lebanon, Pa., is building a number of box cars for the Pennsylvania Railroad.

THE Lafayette Car Works, Lafayette, Ind., are building 50 furniture and 100 box cars for the Northern Pacific Railroad.

THE Carlisle Manufacturing Company, Carlisle, Pa., has a large order for box cars for the Pennsylvania Railroad.

THE Barney & Smith Manufacturing Company, Dayton, O., has an order for 400 box cars for the Northern Pacific Railroad.

THE Jackson & Woodin Manufacturing Company, Berwick, Pa., is building 200 box cars for the Pennsylvania Railroad.

THE Fitchburg Railroad shops at Charlestown, Mass., recently finished 50 stock cars, and have begun work on 400 box cars. All these cars are equipped with the Westinghouse brake.

THE car works of Murray, Dougal & Company, Milton, Pa., are at work on a lot of box cars for the Pennsylvania Railroad.

THE Pennsylvania Railroad shops at Altoona are just now at work on an order for 700 box cars for the road.

THE Dunham Manufacturing Company has recently filled orders for doors for over 2,000 cars, for different roads, including 75 to go to South America.

THE Boyden Power Brake Company has been organized in Baltimore, and will soon secure land and begin the erection of large works for the manufacture of the brakes, which are the invention of Mr. George A. Boyden, of Baltimore. The brake has been successfully tested on the Baltimore & Ohio Railroad.

THE Pullman Car Works, Pullman, Ill., have taken a contract to build 21 passenger cars for the Northern Pacific Railroad.

THE Minnesota Car Company has been organized to build a foundry and car works at Duluth, Minn. It is proposed to build a rolling mill also.

THE Dunham Manufacturing Company, Boston, is increasing its capacity for making its pressed steel stake-pockets for cars, owing to large orders for them. The company is also preparing to meet a large demand for the Servis tie-plate, which has been submitted to severe tests with success.

THE Chicago, Burlington & Quincy shops at Aurora, Ill., are building 12 new passenger cars 54 ft. long and 9 ft. 8 in. wide outside. The inside finish is antique oak, worked into very tasteful form, the carving being neat and artistic. The head linings are maroon colored, very rich looking. Adams and Westlake No. 91 lamps of 65 candle-power are used for lighting. The upper-deck lights are blue glass. There are lavatories at each end of the car, one for men, the other for women. At one end of the car there is a closet for holding small baggage belonging to passengers. The cars are carried on four-wheel trucks having 42½-in. Arbel wrought-iron spoke wheels with steel tires. The outside of the cars is painted Tuscan red, a new departure for the company's passenger rolling stock.

THE Elliott Car Works in Gadsden, Ala., are filling orders for coal and flat cars for the Alabama Great Southern and the New Orleans & Northeastern roads.

THE Anniston (Ala.) shops of the United States Rolling Stock Company are at work on a large order for ore cars for the Alabama Great Southern Railroad.

THE Terre Haute Car Company, Terre Haute, Ind., is building 200 box cars for the Cincinnati, Sandusky & Cleveland road.

Manufacturing Notes.

THE firm of T. William Harris & Company, 44 Broadway, New York, have been awarded the contract for extending the gas works at Dobbs Ferry and Hastings, N. Y. New pipes will be laid at both places.

THE Union Indurated Fiber Company, of New York, is now manufacturing pipes or conduits of its indurated fiber for use in laying underground electric wires. Recently 50,000 ft. of this pipe were laid in Philadelphia.

THE Chicago Steel Rail Company has recently been incorporated in Chicago by Samuel W. Adams, John Good, and others.

THE Hoyt Frog & Crossing Company has been incorporated in Chicago by Frederick J. Hoyt, William E. Wolff, and others.

THE Martin Anti-Fire Car Heater Company, Dunkirk, N. Y., has recently closed contracts to put its heating system in 80 cars for the Wagner Company, and to equip all the passenger cars of the Rome, Watertown & Ogdensburg Railroad.

THE Korting Gas Engine Company has removed its factory and office to new and larger quarters at No. 431 Greenwich Street, New York.

THE Harvey Steel Company has begun to erect works in Newark, N. J., for the manufacture of steel by a new process invented by Hayward A. Harvey.

HOFFMAN & BATES, Portland, Ore., have contracted to build a bridge 270 ft. span at Fall City, Wash. Terr., across the Snoqualmie River.

THE Ansonia Brass & Copper Company, Ansonia, Conn., has begun the manufacture of the Tobin bronze, a new alloy invented by Passed Assistant Engineer John A. Tobin, U.S.N. It is claimed that this alloy is remarkable for its tensile strength, rigidity, and toughness, and that its density and great resistance to the action of salt water make it specially suitable for marine purposes.

THE Industrial Works, Bay City, Mich., have just completed a pile-driver of unusual size for the Denver & Rio Grande road, and a heavy wrecking car for the New York, Lake Erie & Western Railroad.

THE Standard Underground Cable Company, of Pittsburgh, has closed two large contracts for electric-light cables for Chicago. One contract was made with J. P. Barrett, Superintendent of the Electrical Department of Chicago, for five miles of electric light cable, which will connect with the municipal light station of that city and distribute the current to 65 arc lamps, each having a lighting capacity of 2,000 candle-power. The other contract is to furnish 50,000 ft. of cable for the Consumers' Electric Cable Company, of the West Side, Chicago. The incandescent electric light will be used in the latter place.

'Luttgens' Variable Exhaust Damper.

THE accompanying engraving represents a locomotive smoke-stack fitted with the variable exhaust damper invented by Mr. H. A. Luttgens, of Paterson, N. J., which has been in use for four years past, and is now applied to over 100 engines on the New York, New Haven & Hartford, the New York, Susquehanna & Western, the Long Island, and many other roads. This damper is on the double-ender engine of the New York &

Northern Railroad, which was illustrated and described in the October number of the JOURNAL.

In this damper the base of the chimney is made with a number of openings, through which air can be admitted to the stack. On top of these is a circular valve or cover, with corresponding openings, and this can be moved by means of links and a lever operated by a rod from the cab. The engineer can thus admit air, increasing or diminishing the quantity, or shutting it off at will, regulating the draft as required.

This damper has worked well in practice, and it is claimed that it does away with the necessity of opening the fire-door to admit cold air, saves the flues very much, and also secures a considerable saving in fuel.

Marine Engineering.

THE Harlan & Hollingsworth Company in Wilmington, Del., have the contract for a new twin-screw iron steamboat for the New Jersey Central Railroad. The boat is to run between New York and Sandy Hook on the company's Long Branch line, and will be very much like the *Monmouth* which was put on that line last season.

THE William Cramp & Sons Ship & Engine Company recently launched from its yard in Philadelphia a new steel steamship for the Clyde Line. This ship, which is named the *Iroquois*, is

293 ft. long, 46 ft. beam, and 28½ ft. depth of hold, and will carry 2,900 tons on a draft of 15 ft. Her engines will be of the triple-expansion type, with cylinders 23, 36, and 60 in. diameter by 36 in. stroke. There will be four return tubular boilers 11 ft. diameter by 12 ft. long, carrying a steam pressure of 160 lbs. There will be accommodations for 75 first-class passengers. The steamer will be schooner rigged.

Electric Street Railroads.

THE Lynndale street line in Minneapolis, Minn., 3½ miles long, is to be run by electricity. Sprague motors will be used on the cars; the power will be furnished from the Edison electric light station.

THE Thomson-Houston Electric Company has contracted to equip the Cambridge & Arlington Branch of the West End Street Railroad Company in Boston with electric motors. Power will be furnished through an overhead conductor.

THE People's Street Railroad Company will equip its lines in Scranton, Pa., with electric motors. This company has four lines, about 12 miles in all, and 20 cars. The Sprague motor will be used, with overhead conductors.

THE Brookline Branch of the West End Street Railroad Company's lines in Boston is to be equipped with electric cars. The Bentley-Knight conduit system is to be used in the more crowded streets, and an overhead wire on the suburban section. Sprague motors will be used on the cars.

Bridges.

THE Wheeling Union Railroad Company proposes to build a new bridge over the Ohio River at Wheeling, W. Va. It will be a double-track railroad bridge 90 ft. above low water and 2,100 ft. long, with a channel span 535 ft. long. The cost is estimated at $2,000,000.

THE new Central Viaduct in Cleveland, O., which is now approaching completion, has been built by the King Iron Bridge & Manufacturing Company. This viaduct crosses the Cuyahoga River and the adjoining flats. The total length of the bridge is 2,838 ft., and the roadway is 101 ft. above the river. The draw-span at the river crossing is 239 ft. long.

THE Lane Brothers Bridge & Construction Company has been organized at Newark, O., and has taken the business of the former firm of Lane Brothers, bridge-builders and contractors. The change is made in consequence of the death of William H. Lane of the old firm.

Proceedings of Societies.

Master Mechanics' Association.

THE following notice has been issued by the Secretary:

"Mr. J. H. Setchel, President of this Association, has removed to Cuba, N. Y., and that will in future be his address.

"Mr. Angus Sinclair, Secretary, has removed from Chicago, and his office address in future will be, Morse Building, 140 Nassau Street, New York."

Franklin Institute.

THE Franklin Institute, Philadelphia, has issued the announcements for its usual winter course of lectures. Those for November are as follows:

November 5: Feasibility of Underground Railroads in Philadelphia; Professor Lewis M. Haupt, University of Pennsylvania.

November 12: Long Distance Transmission of Power by Electricity; Frank J. Sprague, of New York.

November 19: Some American Contributions to Meteorology; Professor William M. Davis, Harvard University.

November 26: Pig Iron; John Birkinbine, Philadelphia.

New England Railroad Club.

A REGULAR meeting was held in Boston, October 10, President Lauder in the chair.

Mr. George Richards read a paper on Quick Journeys and Fast Running, giving some account of fast trains in this country and abroad, and showing what was needed on a railroad to secure fast time with safety.

This paper was discussed by the President, Messrs. Sinclair, Adams, Davidson, Folsom, Brown, Snow and others.

American Society of Civil Engineers.

A REGULAR meeting of the American Society of Civil Engineers was held October 3, at the Society's House in New York.

A paper was read by John A. Bensel on the New Transfer Bridge, Harsimus Cove, Jersey City, which was followed by a brief discussion.

A paper by George W. Cooley on the Permanence of Bench Marks on Trees, giving the results of many observations, was read by the Secretary and briefly discussed.

A written discussion by C. P. E. Burgwyn of the paper by Colonel William P. Craighill on the Improvement of Several Rivers of the Atlantic Coast was also read by the Secretary. It referred mainly to the work done on the James River and to the improvement effected by the Dutch Gap Cut-off.

The following gentlemen were elected:

Members: William Barker Landreth, Schenectady, N. Y.; Charles Levings, Chicago, Ill.; Charles Abbott Locke, Nashville, Tenn.; Gouverneur Morris, Ardsley, N. Y.; George Thomas Nelles, Leavenworth, Kan.; Frank Chittenden Osborn, Pittsburgh, Pa.; Charles Francis Powell, U.S.A., St. Louis, Mo.; Nathaniel Edwards Russell, Lansingburg, N. Y.; Isaac Austin Smith, Lebanon, Ill.; Linton Waddell Stubbs, Monroe, La.

Juniors: Toragoro Kondo, Kansas City, Mo.; Frank Parsons Lant, Marion, N. C.; Thomas Kennard Thomson, Pencoyd, Pa.

A REGULAR meeting was held at the Society's House in New York, October 17. The Nominating Committee presented a ticket to be voted for at the annual meeting, headed by Mr. M. J. Becker, of Pittsburgh, as President. The Secretary presented a blue-print of one of the pumping engines at the new sewerage works in Boston and several photographs of the Poughkeepsie Bridge.

A paper was read on the Construction of the Sweetwater Dam, San Diego County, Cal., by James D. Schuyler, describing an important masonry dam built to form a large storage reservoir for supplying water for San Diego and also for irrigating purposes. This was discussed by Messrs. Fteley, Francis, Wegmann, Buck, Adams, Croes, Davis, Hunt, Comstock and Cooper. The discussion turned largely on the merits of the arch form for masonry dams, although something was also said of leaks in dams.

Boston Society of Civil Engineers.

THE regular meeting was held September 19, President Fitzgerald in the chair; 48 members and nine visitors present.

Messrs. Louville Curtis and William M. Scanlan were elected members and two names proposed for membership.

Votes of thanks were passed to the various persons who had extended courtesies on the occasion of the Society's visit to Providence and Newport.

A committee consisting of Messrs. J. E. Cheney, D. H. Andrews, and E. S. Shaw was appointed to consider the question of the Proper Inspection of Highway Bridges.

Professor Dwight Porter, of the Institute of Technology, read a paper on the Removal of Roof Water, which was fully discussed by the members present.

Mr. J. Pickering Putnam, Architect of Boston, was introduced, and read a paper on House Drainage, giving the results of his experiments upon the ventilation of traps. The paper was discussed by members of the Society and by Colonel George E. Waring, Jr., of Newport.

Engineers' Club of Philadelphia.

THE first regular meeting of the season was held at the Club's House in Philadelphia, October 6, President Joseph M. Wilson in the chair.

Mr. Frederick Stamm presented a paper on Chimneys for Horizontal Tubular Boilers. The Author discussed the subject of chimney draft under various conditions, and presented formulæ for area of flue and height of stack, with examples.

Mr. H. W. Spangler presented a paper on Leaky Pistons and Indicator Cards.

Mr. Frank Cooper read a paper upon the Economics of Momentum Grades, with Especial Reference to Tributary and Suburban Railways. The object of this paper was to outline a method by which an approximate idea may be formed of the relative effects produced by a succession of sags 26.4 ft. deep, in comparison with a dead-level line of railway, taking various speeds of trains, with stops located from 1 to 10 miles apart. Having determined under fair conditions the energy thus saved, and knowing the average percentage of cost of fuel per train-mile to operating expenses, and to net earnings according to the census of 1880, then applying the percentage of energy saved to this cost of fuel, an estimate may be formed of the value of the principle.

The Secretary presented, for Mr. Robert A. Cummings, a Table of Square Feet in Decimals of an Acre, for the *Reference Book*.

The Secretary made sundry minor announcements.

Engineers' Society of Western Pennsylvania.

AT the regular meeting in Pittsburgh, September 18, Messrs. Thomas F. Cole, Leonard J. Holt, A. C. Linkenheimer, and John G. Park were elected members.

The discussion of Mr. Koch's paper on Open-Hearth Steel was continued by Mr. Hibbard and Professor Phillips.

Mr. Edmund G. Aikman read a paper on the Janney Coupler. This was discussed at considerable length by Messrs. M. C. Becker, E. B. Taylor, C. B. Price, Hibbard, and Roberts. The discussion was continued to the next meeting.

Engineers' Club of Cincinnati.

THE regular monthly meeting was held in Cincinnati, September 5. Two applicants were elected active members, increasing the Club membership to 64.

A standing committee composed of Messrs. G. Bouscaren, M. W. Venable, and E. A. Hermann was appointed to co-operate with other clubs in securing State Inspection of Highway and Railway Bridges.

Mr. Oswald Dietz discussed in a very interesting paper the application of several simple algebraic formulæ to numbers of any magnitude, by which processes of addition, subtraction, multiplication, and division can be performed mentally with great rapidity.

Civil Engineers' Society of St. Paul.

THE first regular meeting of the season was held in St. Paul, September 3, Vice-President Morrison in the chair. Mr. F. W. McCoy was elected Treasurer in place of C. L. Annan, resigned.

Mr. F. W. McCoy read a paper upon Street Improvements in St. Paul, including a statement of the amounts of earth, macadam, and paved streets improved in St. Paul and the cost for the past two years.

Mr. J. D. Estabrook, Superintendent of Parks in St. Paul, followed with an interesting paper upon the Changes of Level in the Northwestern Lakes, illustrated by maps and charts giving the variations in the Great Lakes and others, and comparisons with the rainfall for the last 25 years. This is a subject of especial local interest in reference to Lake Como.

THE regular meeting was held in St. Paul, Minn., October 1. J. D. White, City Engineer of Fargo, Dak., was elected a member.

The form of contract for buildings, as recommended by the National Association of Builders, was submitted, and laid over until the Secretary should correspond with the National Association in regard to the matter.

President Loweth read a paper on Tests of Angle-bars. These tests were made by him in 1887, and tend to throw some light on the effect of rivets and rivet-holes in such members.

Mr. A. Münster read a paper, illustrated by photographic views, on the Highways and Railroads of Norway, showing some striking examples of location and construction.

Engineers' Club of Kansas City.

AT the regular meeting in Kansas City, October 1, Messrs. John M. Waller, S. H. Yonge, and H. H. Filley were chosen members, and S. P. Maybach an associate member. It was announced that rooms for a library and for meetings had been secured, and that papers had been promised for nearly every meeting till March. Several additions to the library were reported.

A letter from Mr. C. R. Taylor, of Philadelphia, was read, describing a new patent for street pavements.

Mr. A. J. Mason read a paper entitled the Complete Sewerage of Kansas City, which was discussed by Messrs. C. W. Pearsons, Gillham, Knight, Kiersted, and Allen.

General Time Convention.

THE fall meeting was held in New York, October 10, with about 75 members in attendance. The date fixed for the general change of time of through trains was November 11.

The Committee on Car Mileage Rates presented a long report, embodying statements of the results obtained from the use of the mixed mileage and per diem rate on a number of different roads. The conclusion reached was that where this system had been tried there had been a considerable increase in the average mileage of the freight cars, showing a gain of nearly 28 per cent. The Committee recommended the continuation and general adoption of the system, and also an increase of demurrage charges from 50 cents to $1 per day. They further recommended that the distribution and movement of cars be placed under control of the transportation department entirely, and that complete statements and daily reports of car movements be adopted. In relation to passenger equipment a rate of $5 per day for passenger and $3 for baggage cars were recommended.

This report brought out a long discussion, at the close of which resolutions were adopted expressing approval of the general plan of mixed mileage and per diem charge for the use of cars, but referring the whole matter back to the Committee with instructions to gather more information, and to recommend the best method of putting the plan into general execution. The rates for passenger equipment were adopted; also the recommendations in relation to the distribution of cars.

The Committee on Train Rules reported that the uniform code adopted by the Convention is now in use on about 30,000 miles of railroad, and enough other companies have announced their intention to adopt it to make the total number of miles committed to the use of the code about 49,000, operated by 79 different companies. The report recommended that standard diagrams be prepared showing the position of flag and lamp signals on engines and cars according to the standard rules, and the Secretary was instructed to have such diagrams prepared.

The Committee on Transmission of Uniform Time announced that arrangements had been made with the United States Naval Observatory at Washington and the Western Union Telegraph Company, by which standard time would be transmitted free once each day to any road desiring it.

The Executive Committee reported a number of amendments to the rules of order, and also recommended that the name of the organization be changed from the General Time Convention to the American Railroad Association. Under the rules these recommendations will come up for discussion at the spring meeting.

American Institute of Mining Engineers.

THE 52d meeting began in Buffalo, N. Y., on Tuesday, October 2. At the opening an address of welcome was made by Dr. Julius Pohlmann, to which the President replied. The President then made an address advocating improvement in existing mining schools and urging that better opportunities be given to students for practice and work. Dr. R. W. Raymond then read a paper on an Ancient Gold Breast-plate found in Central America.

On Wednesday morning the members went to Dunkirk, where they visited the Brooks Locomotive Works and other manufacturing establishments. In the evening a business session was held, and papers were read on the use of Asphalt, by Captain F. B. Greene; on Geysers, by Dr. R. W. Raymond, and on the Life History of Niagara Falls, by Dr. Julius Pohlmann.

On Thursday the members employed their time visiting various points of interest in the neighborhood of Buffalo; in the evening there was the annual dinner of the Institute at the Niagara Hotel.

On Friday two sessions were held. In the morning papers were read on Steel Rails, by Robert W. Hunt, and on Electrical Transmission of Power, by R. P. Rothwell. At the afternoon session a paper on Forestry and Mining was read by B. E. Fer-

now, of the Agricultural Bureau at Washington. A large number of papers were presented by title, according to the usual custom, and will appear in the proceedings of the Institute.

This closed the actual work of the meeting, but the members remained together until Saturday, occupying Friday with visits to the Holly Works and the Cowles Electric Works at Lockport, and Saturday with an excursion to the salt mines of the Retsof Company.

Over 50 new members joined the Institute at this meeting. The spring meeting will be held in New York in February.

American Society of Mechanical Engineers.

THE ninth annual meeting began in Scranton, Pa., October 15. At the opening session an address of welcome by Colonel J. A. Price was responded to by Vice-President C. J. H. Woodbury. Papers were then read on Distribution of Internal Friction of Engines and on Variable Load, Internal Friction and Engine Speed and Work, by Professor R. H. Thurston, and on Friction of Piston Packing Rings in Steam Cylinders, by T. E. Denton.

On the second day, at the morning session, the report of the Council was first presented, and directed attention among other things to the invitation extended by the British Institution of Mechanical Engineers to hold a joint meeting at London next year, and also to visit Paris, where a joint meeting with the British Iron & Steel Institute is in prospect. Messrs. Wiley and Hutton were appointed a committee to give the matter further consideration. Thirty new members, four associates and seven juniors were elected, bringing the total membership of the society up to 903.

Reports were also presented by the Secretary for the Library and Finance committees, the committees on Uniform Tests, Standard Flanges, and Uniformity of Duty Trials of Pumping Engines. Progress in the work of all was reported, and the committees themselves were continued. The report of the tellers, which was then presented, showed that the following officers had been elected for the ensuing year: President, Henry R. Towne; Vice-Presidents, William Kent, Thomas J. Borden and C. B. Richards; Managers, George M. Bond, F. H. Ball and William Forsyth; Treasurer, W. H. Wiley.

A resolution to reduce the number of meetings to one each year was laid on the table after a long discussion.

Papers were read on the Use of Compound Engines for Manufacturing Purposes, by Charles T. Main; on Flow of Steam in a Tube, and on a Simple Calorimeter, by C. H. Peabody.

The afternoon was devoted to a visit to the works of the Lackawanna Coal & Iron Company, and the evening to a reception given by the Scranton Board of Trade.

At the morning session on the third day papers were read on a System of Worm Gearing of Diametral Pitch, by S. W. Powell and W. L. Cheney; Improved Method of Finding Diameters of Cone and Step Pulleys, by C. A. Smith; Strength of Cast Iron, by Professor Gaetano Lanza; Identification of Dry Steam, by J. E. Denton; Cost of Power in Non-condensing Steam Engines, by Charles E. Emery; Counterbalancing the Reciprocating Parts of Locomotives, by Professor Lanza. Topical discussions on Steel Phenomena closed the session.

The afternoon was devoted to excursions to the works of the Dickson Manufacturing Company, the Pine Brook Colliery, the Boies Steel Car Wheel Works, and the works of the Suburban Electric Railroad Company. In the evening another professional session was held, at which special attention was again given to the discussion of Steel Phenomena.

The fourth day was devoted to an excursion to Hawley, Honesdale and over the gravity railroad to Carbondale.

The concluding business session was held on the morning of the fifth day, October 19, at which several papers were read. The usual routine work was attended to and the meeting adjourned, the members dispersing in the afternoon.

Master Car-Builders' Association.

THE following circular has been issued by the Secretary under date of October 12:

"The following questions have been submitted to a letter ballot of the members, with the results given after each question. One ballot was sent without a signature, and therefore was not counted.

"1. To substitute the following for the present standard specification for RUNNING BOARDS: The ends of the running boards of box-cars to be made to project over the ends of the cars, so that the *minimum* distance between the ends of those on adjoining cars will not be over 12 in.; and that the running boards be made not less than 2 ft. wide, and made of three boards 7 by 1 in. The projecting ends to be supported on two brackets, at each end of the car, made of $\frac{5}{8}$ by $1\frac{1}{4}$-in. iron, with a hard wood cleat 3 by 1 in. on upper ends, fastened with one $\frac{1}{2}$-in. bolt and nut in each bracket. The lower end of each bracket to be fastened to the end of the car with two $\frac{1}{2}$-in. bolts and nuts.

"The vote on this substitute for the old standard was 329 'yes' and 84 'no.' The substitute is therefore adopted as a standard of the Association.

"2. To substitute the following for the present standard specification for LADDERS: Each end of every box and stock car to have a ladder attached to it next to the corner which is on the left-hand side when a person is facing the end of the car. The sides of the ladder to be made of two pieces of hard wood $3\frac{1}{2}$ in. wide by $1\frac{1}{4}$ in. thick, each piece to be fastened with four $\frac{1}{2}$-in. bolts and nuts to the end of the car, the narrow sides of these pieces to be fastened against the car. The distance between the strips to be 15 in. Each ladder to have not less than five steps on rounds made of $\frac{5}{8}$-in. round iron; each step to be fastened to the ladder sides with a $\frac{1}{2}$-in. bolt in each end. The lower round to have a guard or projection, to prevent men from slipping when swinging around the end of the car to get on the step. A hand-hold to be attached to the top of the car roof parallel with the ladder rounds 15 in. from the end of the roof. The hand-hold to be made of $\frac{5}{8}$-in. round iron, and to be not less than 17 in. long from center to center of bolt-holes, and to be fastened to the car with two $\frac{1}{2}$-in. lag screws.

"The vote on this substitute for the old standard was 261 'yes' and 171 'no.' The substitute is therefore defeated, not having two-thirds of the votes cast, as required by the constitution.

"3. To substitute the following for the present specification for standard STEPS: Two good substantial steps to be made of wrought iron of $\frac{1}{2}$ by $1\frac{1}{2}$ in. section to be fastened one to each side sill, next to the corner of the car to which the ladder is attached. The steps to be not less than 12 in. long, measured horizontally between the sides, and the tread to be not less than 8 in. below the bottom of the sill. The side of the step next to the corner of the car to be as near to the end of the car as is practicable. Each side of the step to be fastened to the sill with two $\frac{1}{2}$-in. bolts and nuts. A hand-hold to be attached to the side of the car above each step—to be placed horizontally 2 ft. above the bottom of the sills. The hand-hold to be made of $\frac{5}{8}$-in round iron, 2 ft. long in the clear between the ends; to have $2\frac{1}{2}$ in. clear space between it and the sides of the car; to be fastened with one $\frac{1}{2}$-in. lag screw in each end, screwed not less than 2 in. into the framing. Another handle of the same size, and fastened in the same way, to be attached horizontally to the end of the car the same distance above the sills, and on the opposite side of the ladder.

"The vote on this substitute for the old standard was 345 'yes' and 87 'no.' It is therefore adopted as a standard of the Association.

"4. To substitute the following for the present specification for standard BRAKE-SHAFTS: The brake-shaft to be placed on what is the left-hand corner of the car when a person is standing on the track facing the end of the car. The ratchet wheel and brake-pawl to be fastened to a suitable casting attached to the roof. A railing or guard to be attached to the end and the roof of the car around the brake-shaft. The center of the brake-shaft to be 20 in. from the middle of the car. The nuts on the ends of the brake-shafts to be secured by split spring cotters.

"The vote on this substitute for the old standard was 312 'yes' and 102 'no.' It is therefore adopted as a standard of the Association.

"5. To adopt the form and dimensions shown in fig. 3 [not given here] as a standard for axles for cars of 60,000 lbs. capacity.

"The vote on this proposed standard was 224 'yes' and 307 'no.' It is therefore defeated.

"6. To adopt the dimensions given in figures on figs. 4, 5 and 6 [not given here] as standards for stem, dead-blocks and carrier-irons of M. C. B. standard automatic car couplers.

"The vote on this proposed standard was 325 'yes' and 185 'no,' and it is therefore defeated."

Western Society of Engineers.

THE first regular meeting of the season was held in Chicago, October 10. After the routine business had been transacted, the Secretary presented written discussions of Mr. Wisner's paper upon Levels of the Lakes as Affected by the Proposed Lake Michigan and Mississippi Water-Way, from Professor L.

M. Haupt, Professor J. B. Johnson, and Messrs. Clemens Herschel, William P. Judson, Walter P. Rice, and D. F. Henry.

These papers were read and discussed, and the Secretary was authorized to compile the same with explanatory matter for publication. It was announced that other contributions were expected.

OBITUARY.

DENNISON RICHMOND, who died at Syracuse, N. Y., October 4, aged 46 years, had been for 25 years employed as an engineer on the New York State canals. For some years past he had been Engineer of the Middle Division, having charge of all maintenance and repairs.

GEORGE RUMFORD BALDWIN, who died at North Woburn, Mass., October 12, aged 90 years, was a well-known engineer many years ago. He built the Quebec water-works and the Charlestown water-works, designed the Boston marine railway, and took part in the original surveys for the Cape Cod Canal. He was connected at different times with many important works as active or consulting engineer.

JOHN GEORGE BRILL, who died in Philadelphia, September 22, aged 71 years, was born in Germany, but came to the United States when a young man. He began the manufacture of street cars in Philadelphia many years ago, in a small way, gradually increasing the size of his works as the business grew, and finally manufacturing all classes of cars. The firm, for many years J. G. Brill & Sons, was reorganized as the J. G. Brill Company some years ago.

WILLIAM MILLER, one of the oldest and best known iron manufacturers in the West, and Chairman of the Miller Forge Company, Limited, of Pittsburgh, died, September 21, in Allegheny, Pa. He was born in Scotland, and came to America in 1849, connecting himself with the West Point Foundry, at Cold Spring, on the Hudson River. In 1855 he returned to Scotland, but in 1858 settled in Pittsburgh, where he started the West Point Forge, afterward merged in the Duquesne Forge, and finally in the Miller Forge Company, whose extensive works are at Rankin Station, near Pittsburgh.

JAMES L. RANDOLPH, who died at his home near Baltimore, September 17, aged 72 years, received his early training under the late Benjamin H. Latrobe, and was on the Baltimore & Ohio Railroad all his active life. Some three years ago he gave up active work, and was made Consulting Engineer of the company. His work is well described in the following minute passed by the Board of Directors: "Mr. Randolph entered the service of this company in 1836 as Assistant Engineer, and aided in the location and construction of its main line from Harper's Ferry to Wheeling, W. Va. As Chief Engineer of the company he constructed the Washington County Railroad from Weverton to Hagerstown; the Metropolitan Branch from Point of Rocks to Washington; the Somerset & Cambria Railroad from Somerset to Johnstown, Pa.; the Chicago Division from Chicago Junction, O., to Chicago; the Ohio & Baltimore Short line; the Valley Railroad from Harrisonburg to Lexington; the Winchester & Strasburg Railroad; the Hempfield Railroad, and the two massive bridges across the Ohio River, the one between Parkersburg and Belpre and the other between Benwood Bellaire. His name is indissolubly linked with the great engineering works of the Baltimore & Ohio system, and they are striking monuments to his engineering skill and spotless integrity. In these important enterprises he displayed the highest qualities of a civil engineer. Beginning his labors when the railroads of the country were comparatively few, he was forced to deal with many problems which required, from their novelty and complexity, great ingenuity as well as technical skill for their solution. Some of Mr. Randolph's most prominent characteristics were his simplicity and modesty, vigorous commonsense, and strong grasp of the broad principles of engineering."

PERSONALS.

ARTHUR POU is now Chief Engineer of the new Alabama Midland Railroad.

C. A. MERRIAM is now General Superintendent of the San Antonio & Aransas Pass Railroad.

W. G. JOHNSON is now Chief Engineer of the Philadelphia & Atlantic City Railroad.

C. F. BLUE is now General Roadmaster of the Kansas City, Memphis & Birmingham Railroad.

E. L. DUDLEY is now Vice-President and General Superintendent of the St. Paul & Duluth Railroad.

CHIEF ENGINEER N. P. TOWNE, U.S.N., has been ordered to duty in the Bureau of Steam Navigation.

FRANK C. SMITH has resigned the position of Master Mechanic of the Peoria, Decatur & Evansville Railroad.

ANDREW BECKART is now Master Mechanic of the South & North Alabama Division of the Louisville & Nashville Railroad.

COMMANDER WILLIAM M. FOLGER, U.S.N., has been ordered to duty as Inspector of Ordnance at the Washington Navy Yard.

W. G. WILLIAMSON, late City Engineer of Montgomery, Ala., is now engaged in river surveys with the United States Engineer Corps.

JAMES B. HOGG is now Chief Engineer of the Port Townsend & Southern Railroad, with headquarters at Port Townsend, Wash. Terr.

G. W. ETTENGER, late with the Chesapeake & Ohio Railroad, is now Master Mechanic of the Iron Car Company, of New York.

THOMAS F. OAKES, for some time past Vice-President, succeeds Mr. Robert Harris as President of the Northern Pacific Company.

J. A. DROEGE has been appointed Master of Trains of the Atlanta Division of the East Tennessee, Virginia & Georgia Railroad.

J. H. SETCHEL, late Superintendent of the Brooks Locomotive Works, has accepted a position with the Martin Anti-Fire Car Heater Company.

A. P. TUCKER is now General Superintendent of the New York, Pennsylvania & Ohio Railroad. He was recently on the Michigan Central.

WILLIAM PATTERSON has been appointed General Car Inspector for the lines included in the Southern Pacific Company's Pacific System.

O. F. NICHOLS, recently with the Suburban Rapid Transit road, has been appointed Chief Engineer of the Brooklyn Union Elevated Railroad.

CAPTAIN DAVID A. LYLE, Ordnance Department, U.S.A., has been detailed for duty in connection with the U. S. Commission to the Paris Exposition of 1889.

H. C. POTTER, for many years General Manager of the Flint & Père Marquette Railroad, has resigned that position and has gone to Europe for a long vacation.

ROBERT HARRIS has retired from the position of President of the Northern Pacific Railroad Company. He continues a director and Chairman of the Board.

JAMES W. WAY has been appointed Chief Engineer of all the leased and operated lines of the Missouri Pacific Railroad Company, with office in St. Louis.

F. A. GIVEN is now Master Mechanic of the Huntington Division, and W. J. HALLER Master Mechanic of the Newport News Division of the Chesapeake & Ohio Railroad.

COLONEL ROGER JONES, U. S. A., has been appointed Inspector General of the Army, with the rank of Brigadier-General, in place of General Baird, retired from active service.

R. H. SOULE has, it is stated, been offered by the Secretary of the Navy the position of Superintendent of the new ordnance works now being constructed at the Washington Navy Yard. Mr. Soule has, however, declined the position.

GEORGE E. MERCHANT has resigned the position of General Manager of the Western New York & Pennsylvania Railroad, and is now President of the Rochester & Pittsburgh Coal & Iron Company.

J. F. O'BRIEN, who recently resigned the position of General Superintendent of the New York, Pennsylvania & Ohio Railroad, is now General Manager of the Mexican National Railway.

T. W. HEINTZELMAN is appointed Master Mechanic of the Oregon, Benicia and California Pacific divisions and branches of the Southern Pacific Company's Pacific System, having

charge of the Locomotive Works at Sacramento, with headquarters at the latter place.

C. C. WENTWORTH has been placed in charge as Chief Engineer of the construction of the West Virginia & Ironton Railroad, which is an extension of the Norfolk & Western across West Virginia.

WILSON BROTHERS & COMPANY, civil and consulting engineers and architects, have removed their offices from their former location to the new Drexel Building, corner Chestnut and Fifth streets, Philadelphia.

T. M. JACKSON, C. E., of Clarksburg, W. Va., has been appointed Professor of Civil and Mining Engineering in the West Virginia University, and will organize a new course of engineering in that Institution.

CHARLES S. CHURCHILL has been appointed Engineer of Maintenance of Way of the Norfolk & Western road, with headquarters at Roanoke, Va. He was recently in charge of the West Virginia extension of the road.

WILLIAM MCKENZIE is appointed Chief Engineer of Steamers and Master Mechanic of the Western, San Pablo and San Joaquin divisions and branches of the Southern Pacific Company's Pacific System, with headquarters at West Oakland, Cal.

T. WILLIAM HARRIS, of the firm of T. William Harris & Company, New York, has been elected Secretary of the Pomeroy, Middleport & Syracuse Street Railway Company. This road will extend from Middleport to Syracuse, O., a distance of over 10 miles, and will be built in a most thorough manner for a heavy freight and passenger business.

JOHN L. PORTER, who designed and constructed the iron-clad *Merrimac*, is now a ship carpenter in the Navy Yard at Norfolk. In 1844, it is claimed, the thought presented itself to Mr. Porter that a vessel could be so protected by iron plates that the shot and shells of the enemy's guns would have no effect upon her. He constructed a model embodying the idea, but never attempted to build the vessel he had designed. His proposition to make an iron-clad vessel that would float was hooted at. In 1861, after the Confederates had captured the Norfolk Navy Yard, he showed his model to Mr. Marshall Parks (who at that time had charge of the navy of North Carolina), who recognized the value of it and had a bill drafted by himself pass the Legislature providing for the building of the proposed iron-clad. Later the Confederate authorities adopted the plans and decided to use the hull of the old *Merrimac* for the purpose. Six months were required for the completion of the vessel, but great was the rejoicing of the Confederate Government when she smoothly glided into the Elizabeth River. The results are a matter of history.

NOTES AND NEWS.

Aluminium Manufacture in England.—For some time past experiments have been conducted in the neighborhood of London with the Castner process for manufacturing aluminium for use in the arts. The experiments have been so successful that a company has been organized and has nearly completed works at Oldbury, near Birmingham, England, for the production of aluminium and sodium on a commercial scale, under Mr. Castner's patents. These works will have a capacity of 1,500 lbs. of sodium and 500 lbs. of aluminium daily, and both metals will be produced, it is expected, at a price which will make it possible to use them extensively in making steel, bronze, and other alloys.

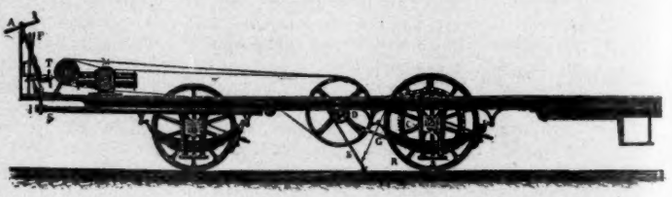
Costa Rica Railroads.—Mr. J. R. Wingfield, United States Consul at San José, Costa Rica, reports that the completed railroads in that country are :

From Port Limon to Corrillo, 70 miles ; from Cartago to Alajuela, passing through San José and Heredia, 25 miles, and from Puntarenas to Esparta, 12 miles.

There are now being constructed 50 miles of new road from Cartago to a point near Siquires, on the Reveutazon River, to complete the connection with Port Limon. These roads are owned by the Costa Rica Railway Company (Limited) of London. To preserve the trade of California with Puntarenas, it is necessary that the road from Esparta be extended to the interior. Otherwise, when through connection is made with Port Limon, upon the completion of the missing link from Cartago, all trade will go by way of Port Limon. It is of the utmost importance to the trade interests of the United States to secure a charter from this Government to run a road from the valley of the San Carlos to San José. The proposed road connecting with the Nicaragua Canal would connect with steamers going both to ports on the Atlantic and on the Pacific. The aggregate exports and imports of Costa Rica last year were $11,000,000, of which the larger portion goes to and comes from Europe.

The Basic Steel Patents.—The *Bulletin* of the American Iron & Steel Association says : "The controversy between Mr. Jacob Reese, of Pittsburgh, and the Bessemer Steel Company, Limited, concerning the ownership of certain patents covering Mr. Reese's inventions in connection with the manufacture of steel by the basic process, has at last been finally disposed of by a verdict in favor of the company. On October 1 the Supreme Court of Pennsylvania, in an opinion by Justice Green, dismissed, with costs to appellant, the appeal of Mr. Reese in the case of the Bessemer Steel Company, Limited, against him to require him to deliver up certain patents for the basic process. There existed between the Bessemer Steel Company, Limited, and Mr. Reese contract relations evidenced by four distinct writings. The specific controversy was whether Mr. Reese was bound to transfer to the Bessemer Steel Company, Limited, all inventions, patents, and applications for patents in existence on September 5, 1879, the date of the principal contract. The Master in chancery decided that such inventions were included in the contract, but limited them to such as related only to the manufacture of steel into rails, ingots, and billets. The Allegheny County Court decreed that all patents were included, and that Mr. Reese must assign them to the Bessemer Steel Company, Limited, for the sum of $32,000. This opinion is now sustained."

Electric Cars in Paris.—An electric car is now in actual service in Paris, on the tramway running through the Avenue de la Grande-Armée. Power is furnished by a battery of 144 accumulators of the Faure-Sellon-Volckmar type, and the usual service is about six hours without recharging. The motor is of the Siemens type, and is carried on the front platform, the connection with the driving-axle being made by chain-belts, arranged as shown in the accompanying sketch. The motor runs at from 1,000 to 1,200 revolutions per minute ; from the motor



shaft *M* the belt runs to the large pulley on the intermediate shaft *P*. This shaft carries two small pulleys, from which two chain-belts, *G*, run over two pulleys, *C*, on the driving-axle. The driving-wheels revolve independently of each other, and can be run at different speeds in passing around curves.

The weight of this car is about as follows :

Car	7,700 lbs.
Accumulators	3,300 "
Motor, pulleys, etc	1,650 "
Passengers (full load)	7,700 "
Total	20,350 lbs.

The car has, like most of the Paris tram-cars, seats on the roof, and can carry 50 passengers when fully loaded.

A Remarkable Railroad.—In the French island of the La Reunion (Bourbon) there is a railroad line which is worthy of note, on account of the many difficulties which were overcome in its construction, arising from the mountainous nature of the island, the rapid and variable streams, the tropical climate, and the nature of the business which it has to carry. This road is of one meter gauge, and is altogether 78 miles in length. There are in this short distance four tunnels, the total length of which is over 6.84 miles, and also many deep cuts and high fills. There are more than 200 bridges and culverts of less than 32.8 ft. in length, and besides these there are 43 large bridges and viaducts having a total length of 8.04 miles. Included in these are three bridges of 328 ft. in length, one of 1,312 ft., and one of 1,640 ft., and a viaduct 431 ft. long and 82 ft. in height. In the original location of the road it was provided that there should be no curve of less than 262.4 ft. radius ; in the final location adopted there are found in three places curves of 351 ft., eight of 410 ft., 12 of 492 ft., and a large number of 656 ft. radius. There is no grade over 2 per cent., but grades from 1½ to 2 per cent. constitute a large part of the road.

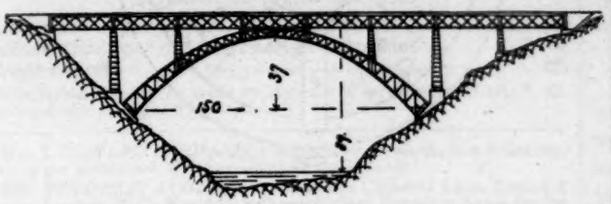
The superstructure is of steel rails of the Vignoles pattern, which were at first laid on prepared wooden ties ; but most of these have been replaced by iron ties of the Livesey system, composed of two angle-irons with a plate prepared to receive

the chair and the bolts fastening the rail; these it is expected will last some time, and will obviate the trouble caused by the very rapid decay of the wooden ties in that tropical climate.

The locomotives used weigh 15 tons, and can haul a load of 50 tons. The passenger cars are 16½ ft. in length, 7½ ft. wide, and have a wheel-base of 6 ft. The freight cars are 13 ft. long, 7½ ft. wide, with wheel-base of 6½ ft.; they weigh 2.5 tons, and carry a load of 5 tons.

The cost of this road, including the tunnels, was over $48,000 per mile, and its construction occupied about three years.

The Paderno Viaduct.—The accompanying sketch gives an outline of a remarkable viaduct recently built over the river Adda near Paderno, Italy, on the new railroad from Seregno to Ponte St. Pietro. This viaduct crosses a deep and narrow valley, and the necessity of building lofty piers has been avoided by the adoption of an arch, as shown. The bridge is 304 meters (992 ft.) over all in length; of this 19 meters (62½ ft.) at either end are occupied by the masonry abutments, and the remaining distance is divided into eight spans of 33.25 meters (109 ft.) each, of lattice girder. These eight spans are supported by the abutments and by seven iron piers of varying height. Three of



these piers, as will be seen from the sketch, are founded directly upon the rocky banks of the river. The remaining four are carried on the elliptic arch which spans the gorge. This arch has a span of 150 meters (492 ft.) and a rise of 37 meters (123 ft.). The total height of the bridge, from the usual level of the river to the bottom of the lower chord, is 89.25 meters (293 ft.).

The bridge has two floors, the railroad track being carried on the lower chords of the girders, while above is an upper floor supporting the carriageway and sidewalks. The design was selected from a number submitted to the Ministry of Public Works by engineers and constructors, and was prepared by J. Rothlisberger, Engineer of the Savigliano Works in Piedmont. It is being constructed by those Works. The dimensions given on the sketch are in meters.

New Shops of the London & Southwestern Railway.—Owing to the increase of traffic and of rolling stock, the locomotive, carriage, and wagon works of the London & Southwestern Company at Nine Elms, near London, have of late been altered and enlarged by Mr. William Adams, the present Locomotive Superintendent. These works now cover 45 acres of ground, and give employment to between 2,000 and 2,500 men.

The locomotive department consists of a number of shops where the various details of the locomotives and tenders are prepared and finally erected into a complete engine and tender. The cylinder shop is provided with a useful overhead traveling crane. Here are also two fine vertical milling and drilling machines. The cylinder-boring machine is adapted for boring two cylinders at one time. The fitting shop is 118 ft. long and 58 ft. wide, and is arranged upon the most approved plan. The brass fitters' shop is 59 ft. long and 45 ft. wide. In this shop is made the white metal piston and valve-rod packing, which is a standard now with all new engines of the Southwestern Railway. The millwright shop is 85 ft. long by 58 ft. wide, and is fitted with all the modern machinery. In it are made the small machines used in the Nine Elms shops. In course of construction is a double-cylinder horizontal steam-engine for the saw-mill. It is intended to run at 140 revolutions per minute, and will drive on to the line-shaft by means of 10 ropes and will be capable of transmitting 350 indicated H. P.

In the machine shop, which is 300 ft. long by 57 ft. wide, all machines of one class are placed together. Screwing machines which are capable of screwing, with excellent finish, 800 copper stays in the course of a day, are found here. In the same shop are numerous small lathes and a massive crank-axle having four rests, all of which may be used at one time.

The erecting shop consists of two bays, each 500 ft. long by 57 ft. wide, which afford accommodation for 70 locomotives. Power is supplied to the small tools in this shop through hydraulic mains at a pressure of 1,500 lbs. per square inch. The boiler shop is 178 ft. long and 116 ft. wide, and is fitted up with the most approved appliances. In the hydraulic engine-house are fixed two pairs of engines which supply water at a pressure of 1,500 lbs. per square inch to an adjoining accumulator, from which all the hydraulic tools in the shop are worked. The smiths' shop contains 26 forges inclusive of bolt-makers' fires. Adjoining the iron foundry, which is served by two five-ton steam cranes, is the brass foundry, which is fitted with Fletcher's furnaces and the usual appliances. The carriage-shop building is 194 ft. long and 60 ft. wide. The running shed, which is capable of holding 60 engines, is 235 ft. wide by 180 ft. long. In this shed is one of Pooley's weighing machines. The carriage paint shop affords accommodation for painting between 60 and 70 coaches.

The London & Southwestern Company operates 850 miles of road; on its lines there are in use 550 locomotives, 3,000 passenger cars, and 8,000 freight cars.

Railroad Accidents in Missouri.—The report of the Missouri Railroad Commissioners for 1887 gives the following statement of casualties on the railroads of the State for the year:

	Killed.	Injured.	Total.
From causes beyond their own control:			
Passengers	2	25	27
Employés	22	96	118
Other persons	21	12	33
Total	45	133	178
From their own carelessness or negligence:			
Passengers	5	15	20
Employés	36	188	224
Others	76	88	164
Total	117	291	408
Total number of casualties:			
Passengers	7	40	47
Employés	58	284	342
Others	97	100	197
Total	162	424	586

The number of employés in railroad service in the State at the close of the year was 25,160.

Concerning safety appliances, the Commissioners speak in the report thus: "The subject of automatic couplers for freight cars has attracted much attention during the past two years, and in some States legislation has been enacted requiring that some approved forms of automatic coupler be adopted. The Master Car Builders of the country have recommended several couplers, from among a very large number submitted to them for consideration, and it seems probable that in the near future all new freight cars built, and all cars sent to shops for repairs, and whose condition will warrant it, will be provided with some approved form of automatic coupler. To attempt at once to apply a new system of couplers and train brakes to the entire equipment of the railroads of the country would entail a very large expense, and which perhaps would not seem reasonable to require. Still, the question of safety to employés and others is a very serious one, and which should be carefully considered, and hardly anything could be deemed unreasonable which would reduce to a minimum the risks to life and limb to which every employé in the train service of a railroad is daily exposed.

"It is doubtless true, that before legislation in regard to safety appliances could be effective, it would have to be general. No single State can effect the needed reforms, and as the question is now one of national importance, and attracting very general attention, it is probable that some steps will soon be taken by Congress in the needed direction. We do not think the time has arrived for legislative action in Missouri in regard to automatic couplers or train brakes, for the reason that up to this time the conclusions of the Master Car Builders and experts in train management are not sufficiently definite to enable the Legislature to act intelligently in the premises, excepting, perhaps, in a general way, but we hope the time may soon arrive when legislative action can be had which will result in the adoption of such appliances as will very largely reduce the present appalling loss of life and injuries to persons resulting from exposure to the many perils of railroad train service."

Tramways in Vienna.—All of the tramways of Vienna are upon the surface of the streets. As yet I have heard of no project for high, or elevated, or subterranean tramways. As regards the return made by the tramway company for the use of the streets of Vienna, I am informed by the Mayor of the city that under the original contract entered into between the company and the city, under date of March 7, 1868, the company was bound to pay 5 per cent. of its gross receipts. Subsequently an agreement was entered into fixing a sum in gross to be paid by the tramway, which sum amounted, in the year 1886, to 125,000 florins ($46,375). In April, 1887, the original contract was again amended, and the compensation to be paid to the city for the use of the streets by the tramway company was fixed at the annual sum of 2,220 florins per kilometer ($1,167 per mile), with

the proviso, however, that the compensation was in no event to be less than 125,000 florins per annum.

The main provisions of these contracts cover the following points:

The plans of the construction of the tramways to be subject to the approval of the Common Council, the Council reserving the right to order any changes it may deem expedient.

All lines of tramways to have double tracks, with a space of at least 11 ft. between the tracks and between track and sidewalk. In narrow streets, a single track, with switches.

The quality of the material of which the tramway is built is prescribed by the contract. No tramway can be opened to the public until its construction is approved by the competent municipal authorities.

Right of way to cross established tramways to be granted to new lines.

The tramway company is held to clean, keep in order, etc., 8 ft. of street for each track. The models for tramway cars to be submitted for the approval of the Common Council.

The company to employ a sufficient number of guards for the safety of the public and for the operation of the road. The instructions for these guards, as well as for the conductors and drivers, to be approved by the Common Council. The contract prescribes the fare and time-table, limits velocity, number of passengers for each car, etc.

The company is held to great care to avoid collisions with wagons, etc., passing upon the streets, and is made liable for all damages arising from such collisions. (The doctrine of contributory negligence seems to have been disregarded.)

New inventions and improvements in tramways to be adopted at request of Common Council. The franchise of the Tramway Company to present holders is not transferable without the consent of the Common Council, and is limited to 35 years.

For each seat of cars in use the company pays in advance 1 florin (37 cents) annually into the pauper fund.

The company is not entitled to claim damages for interference with its traffic by means of movements of troops, public feasts, etc.

At the termination of the franchise the municipality may elect to either take possession of the tramway or to cause its removal, and the restoring of the respective streets to their original condition at the cost of the company.

In the first case, the company must deliver the tracks to the city in good condition and without any compensation whatever. The stables, depots, etc., are to be transferred at their appraised value; but the municipality is not entitled to claim nor bound to accept the transfer of the means of transportation (*transportmittel;* cars).

The company is obliged to deposit as security for the proper observance of the conditions of the contract the sum of 300,000 florins ($111,300) in city securities. In case the company fails to fulfill any of the conditions of the contract, the Common Council reserves the right to declare any portion of the indemnity found forfeited in its own motive, and without any interference on the part of the judicial tribunals or administrative authorities.—*Report of U. S. Consul-General Edmund Jussen to State Department.*

A New Vibrating Engine.—There is being built in Portland, Me., an engine which is the invention of Mr. Lidback, which has quite a number of novel features. I have called it a vibrating engine to distinguish it from a rotary, as the driving apparatus turns through part of a circle. The piston consists of a hollow cylinder, having four wings on its outer side. The outer edges of these wings carry packing pieces, which bear against the inner surface of the steam cylinder proper. Between the wings rectangular plates extend inwardly from the steam cylinder, which are made to bear against the outside of the cylindrical part of the piston. Each wing of the piston is therefore between two of these plates, and moves backward and forward as the piston vibrates. Fig. 1 will give a fair idea of the arrangement of the parts. *A A* is the piston carrying the wings *B B B B*, each of which is packed by the rectangular piece *C* against the interior of the cylinder *D*. *E E E E* are the plates fitting into recesses in the cylinder *D*, and set up by set-screws, two of which are shown at *F F*. *H* is the valve chamber, and steam is admitted through the center of the piston. Ports are cut through the piston *A* at *G G*. Two ports, one for steam and one for exhaust, are in each corner, but one lies at one end and one at the other of the piston *A*. The valve used is represented in fig. 2. It consists of a cone-shaped piece of cast iron, *H*, having steam ports, *I*, and exhaust ports, *K*, cut in it. Steam is admitted through the pipe *L*, and passes through *I* into the opening in the piston and into the cylinder. The exhaust is taken through the port *K* into the exhaust pipe. With larger sizes separate valves are used, and do away with heating the exhaust from the live steam. The spindle supporting the piston passes through a long bearing, and carries on its end an arm to which the connecting rod is attached. The flywheel shaft is carried in the same casting, and is directly over the cylinder. It is driven directly by the connecting rod, and carries on it what is practically an eccentric for moving the valve. On the smaller sizes a throttling governor is used, but on larger sizes a shaft governor is fitted, which varies the point of cut-off. A 10 H.-P. engine, single cylinder, weighs about 600 pounds complete, while a 10 H.-P. compound weighs a little over 300 pounds. They can be run satisfactorily up to 1,000 revolutions, but generally are speeded at about 250. As the most important thing about an engine of this kind is the method of making the piston steam-tight, it is here more fully described. The rectangular pieces *C*, fig. 1, fit snugly into the recesses prepared for them, and as the steam is admitted on one side or the other, they are thrown against the opposite side and out against

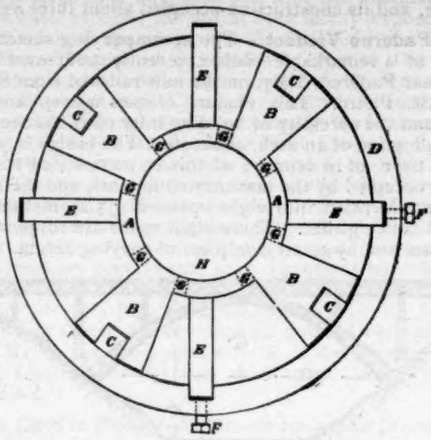


Fig. 1.

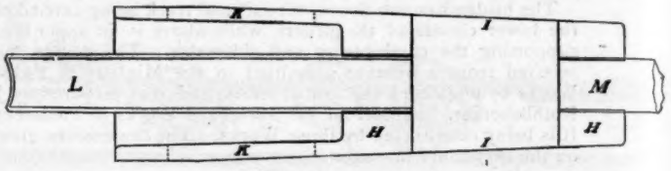


Fig. 2.

the cylinder by the steam pressure. The plates *E* are carefully finished along the inner edge and are set up from the outside. Steam is prevented from passing over the ends of the vanes or wings. At one end the piston-head is fitted against the end of the cylinder and piston by scraping, and the plates *E* are recessed into the head. The other end of the cylinder is made of a plate, which is recessed for the ends of the plates, allowing a movement

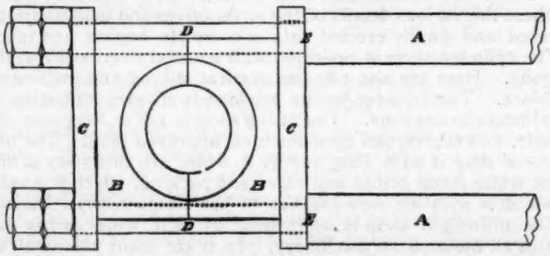


Fig. 3.

of the plate axially, and the piston and the plate present scraped surfaces to each other. This plate is set up by set-screws on the outside. The tightness depends, therefore, on the accuracy of the surfaces originally and the care with which it is set up. Engines have been built varying from one and one-half to 100 H. P., and have proved to be as tight as desired. The small floor space and head room required is not the least of the advantages of these engines. The connecting rods are quite ingenious and to me new. The brasses for each end are cast and fitted as shown in fig. 3. The two ends are alike. *B B* are the brasses; *C C* are two rectangular plates fitting over the rods *A A*, which are smaller at *D* than at *A*, having a shoulder at *E*. The brasses and plates are held on by the nuts, as shown. The brasses are prevented from moving, as the rods *D* are recessed into the sides of the brasses.—*H. W. S., in Journal of the Franklin Institute for October.*